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THE HISTORICAL DEVELOPMENT OF RESPONSE PSYCHOLOGY[1]

By Professor HERBERT S. LANGFELD

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THERE are, I venture to say, few psychologists of the present day so thoroughly mentalistic that they do not incorporate some form of motor response in their psychological system. Where they differ is in the importance they attach to such responses and in the relation they believe exists between response and consciousness. The prevailing, and what might be considered the conservative view, is that response follows perception or ideas either as an effect or as an accompaniment and that such conscious states are only affected by response in so far as such response stimulates proprioceptors, which in turn set up an afferent impulse. According to this view, then, consciousness lies, as it were, between the afferent and efferent impulses and consequently occurs before the response. In a previous paper I have described a view which makes response an essential factor of consciousness.[2] It follows from this position that without response there would be no consciousness. No matter how many or how strong are the stimuli and the resulting afferent impulses, without the efferent impulses and specific response, either incipient or overt, an organism would have no awareness of a world; so far as that organism is concerned there would be no experience.

This view undoubtedly seems extreme to many scientists, but it does not in the least break with the past, nor is it new in any of its essential features. It is my purpose, then, in this paper to sketch briefly its historical development and to describe some of the more recent experimental findings which seem to support it. I should say, at the outset, that many of the authors of the past, especially those who wrote before the birth of experimental psychology, made but brief reference to such a view, and no one of them devel-

[1] Address of the vice-president and chairman of Section I—Psychology, American Association for the Advancement of Science, Atlantic City, December, 1932.

[2] H. S. Langfeld, "A Response Interpretation of Consciousness," *Psychol. Rev.*, 38: 87–108, 1931.

oped a consistent and thorough response theory. But it is fair to assume that even a chance remark from a respected philosopher or scientific man has often had a strong influence on the future of thought.

There are many of our present psychological concepts whose roots can be traced to the early Greek philosophers. In support of our present thesis we find Plato's identification of thought with inner speech. Inner speech, however, can as well be accepted by the mentalist as by the response psychologist, for the remark may simply mean that we hear ourselves think and need not necessarily refer to incipient response of the vocal organs. Therefore, unless we wish to force the interpretation of Plato's statement, one can only assume that at best it was merely a faint but nevertheless fruitful suggestion. Parmenides, before him, however, wrote in no uncertain terms. He does not even mention vocal response, but takes us at once to the gross movements of the organism. "For just as thought finds at any time the mixture of its erring organs, so does it come to men, for that which thinks is the same, namely, the substance of the limbs, in each and every man; for the highest degree of organization gives the highest degree of thought."[3] Not only did Parmenides plainly identify thought with motor response, but he even went further and, to recast the statement in modern terms, correlated degree of intelligence with degree of muscular coordination, which was the underlying idea in some recent investigations of the relation of intelligence scores to the speed of reaction.

Many centuries later, La Mettrie referred to the identification of thought, or as he called it "faculties of the soul," with the organization not only of the brain but of the entire body.[4] He further stated "that thought is so little incompatible with organized matter, that it seems to be one of its properties on a par with electricity, the faculty of motion, impenetrability, extension, etc."[5] This, the basis of his materialism, is a very general statement. A more specific reference to a response theory is his remark that "the brain has its muscles for thinking, as the legs have muscles for walking."[6] Such a phrase would be highly fantastic from any other point of view than a motor concept of thought, and even his sharpest critic would hardly accuse La Mettrie of phantasy or mysticism.

In much of the literature upon motor response, kinesthesis plays an important if not a leading rôle. There is, in such instances, it seems to me, a serious confusion, as I have explained elsewhere.[7] According to a thoroughgoing motor theory, perception is identical with the response system, not a consequence of it, and kinesthesis, being a perception, must therefore itself be identified with such response. The motor theory does not in any way depend for its verification on introspective reports of kinesthesis. Even if we never had a perception of the feel of our muscles, the motor theory would in no wise be invalidated. As a matter of fact, relative to the total perceptual experience of the individual, kinesthesis is a rarity and, further, it is obvious from what has just been said that for a psychologist to dwell upon the function of kinesthesis does not in itself class him as a response psychologist. If such were the case, there would be very few psychologists who do not fall under that category. In short, kinesthesis can as well fit into an afferent-perception-efferent-response theory as into a response or motor theory. And so when Erasmus Darwin stated in his "Zoonomia" that "the organ of touch is properly the sense of pressure, but the muscular fibres themselves constitute the organ of sense, that feels extension," he does not commit himself to any particular theory.[8] It is difficult for us to-day to interpret accurately this statement which, in the light of our finer distinction of terms, appears to us ambiguous, and this holds for several other authors I shall quote, whose descriptions are in sensory rather than motor terms. When, however, he further states that ". . . the whole muscular system may be considered as one organ of sense, and the various attitudes of the body, as ideas belonging to this organ," there can be little doubt that he attached much importance for consciousness to the motor side of the total organic response.

Professor L. Carmichael in his article on Sir Charles Bell[9] has shown how amazingly broad and prophetic were that scientific man's views on physiology and psychology. It is not surprising, therefore, to find that Bell was cognizant of the important rôle of muscular action in perception, especially in the experience of space. In his book on "The Hand"[10] he remarks that "without a sense of muscular action or consciousness of the degree of effort made, the proper sense of touch could hardly be an inlet to knowledge at all." Just as in one of the above statements of Darwin, so here it is not clear

[3] J. Burnett, "Early Greek Philosophy," 2nd edition, 1908, p. 202. The last clause is G. H. Lewis's translation in his "Biographical History of Philosophy," 1905, Parmenides, 51–52.

[4] La Mettrie, "Man a Machine," p. 128. Chicago, Open Court Pub. Co., 1912.

[5] *Ibid.*, pp. 143–144.

[6] *Ibid.*, p. 132.

[7] H. S. Langfeld, "A Response Interpretation of Consciousness."

[8] Erasmus Darwin, "Zoonomia, or the Laws of Organic Life," Vol. 1, Sect. xiv. London, 1794.

[9] L. Carmichael, "Sir Charles Bell: A Contribution to the History of Physiological Psychology," *Psychol. Rev.*, 33: 188–217, 1926.

[10] Sir Charles Bell, "The Hand," London, William Pickering, p. 195, 1833.

to what extent reference is made merely to kinesthetic sensations. Further, it is not safe to conclude that Bell believed the sensation of touch to be dependent upon motor experience. I am inclined to think, rather, that he had in mind touch localization. Certainly, when he stated that "it is to the muscular apparatus and to the conclusions we are enabled to draw from the consciousness of muscular effort, that we owe that geometrical sense by which we become acquainted with the form, and magnitude, and distance of objects," he is referring to the genetic theory of space based upon movement.[11] Although there may be some doubt from these earlier writings of Bell's adherence to the notion that movement is a *sine qua non* of touch perception, there is little possibility of mistaking his meaning in the article he wrote some twenty years later, entitled "On the Necessity of the Sense of Muscular Action to the Full Exercise of the Organs of the Senses."[12] The title itself is clearly indicative of his position, and Carmichael has pointed out that Bell believed that the stimulation of the sensory nerve was not sufficient for a perceptual experience. Something more is necessary, namely, muscular movement.[13] In other words, Bell held that the total afferent-efferent system is a true correlate of the perception.

Seven years before Bell wrote this last-mentioned paper appeared Baron von Holbach's English translation of the "System of Nature," the original of which was published in 1770. In it he expressed the view that consciousness depends upon organization and specific action. He speaks in the language of the time, but the thought is distinctly modern in that he emphasizes action patterns. "To convince ourselves," he wrote, "that the faculties called *intellectual* are only certain modes of existence, or determinate manners of acting which result from the peculiar organization of the body, we have only to analyze them: we shall then see, that all the operations which are attributed to the soul, are nothing more than certain modifications of the body, etc., etc."[14] This remark refers not only to the doctrine that the mental does not exist without the physical, but also that response is a necessary factor.

In the beginning of this same century, 1801, Destutt De Tracy, in his "Elemens d'Ideologie,"[15] expressed similar views of the direct relation of movement to the mental. He considered "it certain that we cannot conceive of any perception produced in us, even the most purely intellectual, without some kind of movement in some one of our organs." One might think from this statement that he was describing that relation of ideas to action, which later took the form of the ideo-motor theory: but from his further remarks that we can only regard action of thought and of sensing as a particular effect of the act of moving ourselves and that "this notion is worthy of serious consideration," it is clear that he was not thinking of the possibility of movement always following an idea, but rather of the dependence of the idea on the movement.

Of the work of the middle of the last century, Lotze's theory of local signs and his genetic interpretation of space perception have a significant bearing on the motor theory. His idea that spatial localization depends on muscular movement means that at least some quality of our mental experience is in direct relation to if not identical with response. It is true that Lotze spoke of "Muskelgefühl" and thus invited the criticism that sensations of movement can not by some magical alchemy become visual perceptions. We find here the old confusion, noted above, between kinesthesis or feeling of movement and the efferent impulse and the movement itself.

Alexander Bain described localization in terms very similar to those of Lotze, and unfortunately with the same confusion. He states: "An object seems to us to be up or down, according as we raise or lower the pupil of the eye in order to see it; the very notion of up and down is derived from our feelings of movement, and not at all from the optical image formed on the back of the eye." He comes very much closer to the present conception of the rôle of response when he writes: "And now, as to the *sensations,* or the proper mental elements of Sight. These are partly optical, resulting from the effect of light on the retina, and partly muscular, arising through the action of the various muscles. Nearly all sensations of sight combine both elements."[16] There is evidently here a direct reference to movement itself. Bain further specifically calls attention to the function of the organs of speech and believes that "a *suppressed articulation* is in fact the material of our recollection, the intellectual manifestation, the *idea* of speech."[17] He also combats the notion that the brain is the seat of sense impressions and believes emphatically that the total nervous arc is necessary for consciousness, a view which was later elaborated by Professor John

[11] Sir Charles Bell, "On the Motions of the Eye, in Illustration of the Uses of the Muscles and Nerves of the Orbit," *Phil. Trans. Roy. Soc. Lond.*, pt. 1, p. 167, 1823.

[12] Sir Charles Bell, "On the Necessity of the Sense of Muscular Action to the Full Exercise of the Organs of the Senses," *Proc. Roy. Soc. Edinburgh*, 361–363, 1842.

[13] L. Carmichael, "Sir Charles Bell: A Contribution to the History of Physiological Psychology," p. 209.

[14] Baron von Holbach, "System of Nature," English translation, Vol. 1, p. 53, 1835.

[15] Destutt De Tracy, "Elemens d'Ideologie," Paris, 3rd ed., Chap. xii, 1817.

[16] Alexander Bain, "The Senses and the Intellect," p. 246, 4th ed., New York, Appleton, 1894.

[17] *Ibid.*, p. 357.

Dewey.[18] In Bain's words, ". . . nervous action supposes currents passing through these completed circles, or to and fro between the central ganglia and the organs of sense and motion; and that, short of a completed course, no nervous action exists."[19] Continuing, he explains thought by the same nervous mechanism. After citing the example of persons who talk to themselves, he expresses the opinion so frequently quoted that "the tendency of the idea of an action to produce the fact shows that the idea is already the fact in a weaker form. Thinking is restrained speaking or acting."[20]

George Henry Lewes recognized the importance of the motor processes as shown in his statement that "every psychical fact is a product of sense-work, brain-work, and muscle-work,"[21] but one can not say that he ever held to a strictly motor theory of consciousness. His remark that ". . . in all cases an action of some kind results; directly or indirectly, every sensation is *completed* in an action; and thus Action is the pole-star of even the most wide-wandering Speculation"[22] is evidently a formulation of the ideo-motor theory.

It is difficult to evaluate Mach's contributions to the motor theory, for his statements are strangely contradictory. His "thought experiment," so far as we can judge from his description, remains entirely in the realm of ideas. In connection with space, both visual and tactual, he recognizes the importance of the muscles and shows in some detail how they contribute to breadth, depth, right, left, symmetry, etc. If he had throughout been consistent with his statement that "the will to perform movements of the eyes, or the innervation to the act, is itself the space-sensation,"[23] there would be no doubt that at least in spatial experience he was a thoroughgoing motorist, but he later states that it is hard to decide whether "the innervation itself is the space-sensation, or whether . . . the space-sensation is before or behind the innervation."[24] And further on he remarks, "In so far as we have spatial perceptions, these depend, according to our theory, on sensations. What is the nature of these sensations, and what organs are active in connexion with them, we must leave an open question."[25] When he comes to the problem of time, a phenomenon which he would have had little difficulty to explain in motor terms, he assumes a special time sense. In regard to music he clearly denies any function to the response mechanism, for he says, "Music can no more come into being merely through the motor sensations accompanying musical performances, than a deaf man can hear music by watching the movements of players."[26] It is evident from the above quotations that he started with a clear-cut motor concept and became less sure of it as he proceeded.

Georges Dubreuque in his article on "L'Intuition Motrice" in 1898 remarked that Condillac's great mistake was to omit from his statue the principal phenomenon which is necessary in the acquisition of sensation, namely, movement. He discusses in particular the perception of space and numbers which he believes require movement for their realization. His notion that the concept of numbers and such mathematical constructions as infinity have their origin in the response mechanism seems well founded on fact. Similar ideas regarding the origin of mathematical concepts have appeared in recent writings, such as that of Dr. P. Chaslin.[27] In reference to space Dubreuque remarks that it is quite possible to have the perception of an empty space, that is to say, a space without objects. For even though there would be no tactile or visual sensations, there would still be motor sensations.[28]

William James's dualistic view-point colored all his writings. It can not be said that he ever subscribed to a strict motor theory, even though he gave the motor processes a very important place in his psychology. Although not the originator of the principle of the ideo-motor theory, his name is usually associated with the theory, due to the prominence he gave it. But the ideo-motor theory, as its name implies, presupposes the existence of conscious processes before the response, and merely asserts that response is an invariable consequence of idea. It is only in so far as this theory emphasizes the necessity of response that it is a contribution to the development of the motor theory. The same qualification must be made in regard to the James-Lange theory of emotion. Here, too, a dualism underlies the concept. If we could stop with the bare statement that the bodily responses are the emotions, that is to say, identical with the consciousness of the emotions, we would be justified in claiming James as a motor theorist. But James went on to explain that it is our consciousness

[18] John Dewey, "The Reflex Arc Concept in Psychology," *Psychol. Rev.*, 3: 357–370, 1896.

[19] Alexander Bain, "The Senses and the Intellect," p. 355.

[20] *Ibid.*, p. 358.

[21] George Henry Lewes, "Problems of Life and Mind," Vol. 1, p. 147, 1874.

[22] *Ibid.*, p. 145.

[23] E. Mach, "The Analysis of Sensations," p. 129. Tr. by C. M. Williams, Chicago, Open Court Pub. Co., 1914.

[24] *Ibid.*, p. 170.

[25] *Ibid.*, p. 184.

[26] *Ibid.*, p. 280.

[27] P. Chaslin, "Essai sur la Mechanisme Psychologique des Opérations de la Mathématique Pure," Paris, 1926.

[28] G. Dubreuque, "L'Intuition motrice," *Rev. Phil.*, 46, p. 291, 1898.

of these processes which constitute the emotions, in other words, that the afferent impulses back to the brain from the periphery are necessary for the consciousness of the emotion. Dr. Walter Cannon, it seems to me, was correct in rejecting this part of the theory, although on the basis of the motor theory I can not agree that the response as such is not an integral part of the physiological pattern of the emotions. It might be added that James comes very close to a motor theory when he stated that "no impression or idea of eye, ear, or skin comes to us without occasioning a movement, even though the movement be no more than the accommodation of the sense-organs; and all our trains of sensation and sensational imagery have their terms alternated and interpenetrated with motor processes of most of which we practically are unconscious."[29] This statement seems indeed to imply a step beyond the ideo-motor theory.

Hugo Münsterberg made a most signal contribution to response psychology with his action theory. For him the response is a necessary factor for consciousness in that the degree of openness of the motor channels is in direct relation to the degree of vividness of the mental process. Although Münsterberg did not identify response with consciousness, since he placed mental phenomena in another universe of discourse distinct from that of physiological processes, and although he was concerned particularly with the one attribute of vividness of consciousness, yet he and his pupils were primarily interested in the response phase of experience in their experimentation.

In 1899, Professor B. B. Breese, a pupil of Münsterberg, gave a very clear and concise exposition of the motor theory. In his own words, "Consciousness . . . depends for its existence and character upon the transference of sense stimuli into motor paths. This hypothesis considers the incoming, or sense stimulation, and the out-going, or motor innervation, as a single nerve process. There is no point of separation between them. The motor discharge is necessary in order that any central activity take place."[30] In experiments on retinal rivalry Breese found that the time of retention of the field before one eye was increased by the contraction of the muscles of the right or left side of the body respectively. From the results of his experiments on retinal rivalry he concludes that "in general, *inhibition of the motor elements tends to inhibit consciousness.*"[31] He is even more emphatic when he states that "the limitations of the motor adjustments become the limitations of thought,"[32] which means, if this is true, that we should expect to find a correlation between thought and muscular coordination. In regard to the inhibition of the spoken word during the learning of nonsense syllables by requiring the subject to count during the learning, Breese remarked that the increase of errors was not due to distraction but to the fact that the words could not find their natural expression in vocalization.[33] That is to say, the proper motor adjustment for the series was partially inhibited. Experiments recently conducted by Mr. Michael Blankfort in the Princeton Laboratory on the rôle of the motor processes in learning seem to confirm the assertion of Breese that the distraction was not the main cause of the increase of errors. In Blankfort's experiment the subject performed an act of skill with one hand, while the other hand merely carried out simple tapping movements during one series and remained idle during the other series. There was a greater transfer of training from one member to the other when the hand not performing the main task was idle. Check experiments indicated that distraction was not the cause of the difference. The explanation seems to lie rather in the fact that the other hand, when idle so far as a definite task was concerned, could carry out incipient responses similar to the movements of the hand performing the skilled movements, and was thus practising synchronously with the latter hand.

Josiah Royce believed in the close relationship of ideas and activity. Thought, for him, is "our consciousness of an act or of a series of acts adjusted to an object, in such a wise as fittingly to represent that object, etc."[34] He believed further that our mental images of an object can not be separated from our response. It is not clear, however, just where Royce places the motor process, but it is fair to assume that he did not unequivocally identify motor processes with consciousness.

Theodore Ribot throughout his writings insisted upon the importance of the rôle of movement in mental life. He has expressed himself most decidedly, perhaps, in his "Psychologie de l'Attention."[35] He asks if "the movements of the face, the body, the limbs, and the respiratory changes, which accompany attention, are as is usually asserted merely effects, signs." Are they not, on the contrary, he questions, "the necessary condition, the indispensable factors of attention"? He holds the second thesis, for, as he says, "if one suppresses all movement one entirely inhibits attention."[36] He argues for a motor theory of attention in terms similar to those used by James

[29] W. James, "Principles of Psychology," p. 581, Vol. 2, London, Macmillan, 1901.
[30] B. B. Breese, "On Inhibition," *Psychol. Rev. Monog.*, 3: 47–48, 1899.
[31] *Ibid.*, p. 58.
[32] *Ibid.*, p. 62.
[33] *Ibid.*, p. 58.
[34] Josiah Royce, "Outlines of Psychology," p. 285, New York, Macmillan, 1906.
[35] Theodore Ribot, "Psychologie de l'Attention," Paris, Alcan, 1906.
[36] *Ibid.*, p. 32.

for the emotions when he says that if a spectator at the opera could suppress all responses of the eyes, head, etc., what would remain of attention would be a very empty function, would in fact not be attention at all.[37] He further makes the emphatic statement that we must either assume elements of movement in all cases of voluntary attention or admit that an explanation of the mechanism is impossible.[38]

During the first decade of the present century a number of French psychologists incorporated the motor theory in their explanation of mental phenomena. B. Bourdon[39] attributes a secondary rôle to tactual and muscular sensations in the perception of form. As he uses the term sensation rather than response, it is probable that he had merely kinesthesis in mind. Dr. R. Nuel, on the other hand, is more explicit in his book on "La Vision." "The visual phenomena," he explains, "are entirely motor. There can be absolutely no question of visual consciousness in the infant before it has made bodily responses to visual stimuli."[40]

Dr. N. Kostyleff tries to break from an explanation of experience in purely mental terms by his theory of reflexes. For example, in discussing abstract ideas, he states that "it is only necessary to substitute for a psychological explanation the objective notion of reflexes in order that the general scheme of an objective explanation shall form a clear picture."[41] Throughout his writings Kostyleff makes constant use of the term reflex, and it is unfortunately not always clear what he means exactly by this expression. In fact, one gains the impression at times that it may be one of those magical phrases which are supposed to solve all psychological problems.

P. Souriau, writing about the same time as Kostyleff, implies an acceptance of the response theory so far as the emotions are concerned. For example, he remarks that the drop of the mouth which is a sign of sadness is without doubt the sadness itself.[42]

Professor Judd in a series of articles has explained the functional nature of the efferent response in a manner with which I find the theory I have expressed here and elsewhere to be in entire agreement. In criticizing the long-discarded innervation sensations, he makes it evident that the motor theory does not imply a direct representation in consciousness of the efferent impulse, but rather that consciousness is functionally dependent upon it. He rightly states that the advantage of the innervation theory was lost by calling the conscious processes innervation sensations. He regrets that no one had "asserted that the outgoing motor processes are indeed related to consciousness, but not in such a way as to arouse new sensations, etc."[43] In "What is Perception?"[44] he describes the function of motor tendencies in spatial perception and in the "Motor Processes and Consciousness" the unifying functions of such tendencies. "Unity of percepts," he writes, "and unity of ideas are . . . phrases which describe an aspect of consciousness dependent on motor tendencies."[45]

In the minds of the present-day psychologists, the motor theory is most closely associated with the names of Professor Washburn and of Professor Holt. Space does not permit a review of the many important contributions to the subject which Washburn has made, beginning with the book on "Movement and Mental Imagery."[46] Nor is such a review necessary in this place, since she has been extensively quoted in recent articles on response. Holt has not written so much directly on the motor theory, but the monistic view of consciousness and the identification of response with consciousness form the foundation of all his work. Perhaps the most concrete exposition of his view is to be found in the Supplement to "The Freudian Wish" on "Response and Cognition." To quote one phrase from this chapter, "The volitional element in behavioristic attention will be, . . . the process whereby the body assumes and exercises an adjustment or motor set such that its activities are some function of an object; are focused on an object."[47] He goes on to show that the behaviorists in describing objective action are describing consciousness.

Dr. Eugene Posch's psychology[48] is in close agreement with Holt's views. Posch explains the higher mental processes as well as the sensations in terms of verbal and postural response, muscle tonus and innervation. At about the same time as Posch, Dr. R. Müller-Freienfels published his views on the nature of thought and phantasy. He also stresses motor responses as essential to thought, but he does not

[37] *Ibid.*, 37–38.
[38] *Ibid.*, p. 73.
[39] B. Bourdon, "La perception visuelle de l'Espace," Paris, Schleicher Fréres, 1902.
[40] R. Nuel, "La Vision," p. 256, Paris, Doin, 1904.
[41] N. Kostyleff, "Les Substituts de l'Ame dans la Psychologie moderne," p. 194, Paris, Alcan, 1906.
[42] P. Souriau, "La perception des Faits psychiques," p. 56, *Année Psychol.*, 1907, 13.
[43] C. H. Judd, "The Doctrine of Attitudes," *Jour. Phil., Psychol. and Sci. Meth.*, 5, p. 682, 1908.
[44] C. H. Judd, "What is Perception?" *Jour. Phil., Psychol. and Sci. Meth.*, 6, 36–44, 1909.
[45] C. H. Judd, "Motor Processes and Consciousness," *Jour. Phil., Psychol. and Sci. Meth.*, 6, p. 91, 1909.
[46] M. Washburn, "Movement and Mental Imagery," Boston, Houghton Mifflin, 1916.
[47] E. B. Holt, "The Freudian Wish," p. 178, New York, Henry Holt, 1915.
[48] Posch published a book in Hungarian in 1915 which was finished in 1911. I obtained his views from an article entitled "Umriss einer realistischen Psychologie," *Arch. f. d. ges. Psychol.*, 1923, 44, 191–243, in which he summarized the contents of his book.

consider them the exclusive condition of mental processes.[49] Posch states that he is in accord with Müller-Freienfels, except in so far as the latter retains a remnant of ideational elements in his theory. Posch affirms that "What one calls ideas, memory pictures, visual images, etc., can one and all be entirely resolved in attitudes, poses, etc., and must be, if one is to pursue a realistic psychology."[50] He holds to a strict monism and vigorously attacks the notion that mental qualities reside in the brain.

Professor J. F. Dashiell has given a clear account of the identification of the whole nervous arc with consciousness. He translates the thought experiment of Mach into motor terms. In his words, "if, now, we recognize that the process of thinking differs from any other trial and error activity mainly in degree of explicitness, are we not presented with another physiological conception of thinking, an alternative to the intra-cerebral conception. . . .?"[51] And on the subject of meaning he states that "it is my thesis that such abbreviated, anticipatory reactions aroused by a thing are that thing's meaning."[52]

The phenomenon of empathy, as described by Lipps, Vernon Lee and others, is a striking example of the function of the motor processes and can only, it seems to me, be explained by the motor theory. The work of neither of the above-named authors, however, did more than suggest to future writers the possibility of such an explanation. Dr. H. Friedländer, on the other hand, makes a contribution to both empathy and the motor theory in his description of the perception of weight when he states that, "The sensations in the arm, hand, and finger are almost entirely absent from consciousness and the object is filled with a 'sensory something' that appeared directly as the *weight* of the object. *This weight formed a unity with the visual appearance of the object.*"[53] It must be said, however, that Professor David Katz and his pupils, of whom Friedländer is one, can not be classed as motor theorists. It is true that we find many statements like the above which could well have been written by an adherent of the motor theory. Katz, for example, states that "we *produce* quasi through our muscular activities characteristics such as roughness and smoothness, hardness and softness; we are really the *creator of these qualities.*"[54] We also find them referring to movement as a form-giving factor and they give many results of their valuable researches which can well be interpreted according to the motor theory, but they always refer to kinesthesis in their own descriptions.

In England Professor S. Alexander is the chief exponent of a motor theory and many of his writings are based upon this concept. It would be difficult to find a clearer account than the following: "all knowledge from bare sensation up to the highest truth is revealed to our apprehensions and revealed through action."[55] And further, "The older writers used to say that afferent nerves conveyed sensations to the brain and mind, awakening there pictures which represent external things, upon which pictures we then behave appropriately. These pictures are mythology, and exist only in the fancy of theorists who are not content with facts. What the afferent nerves convey to the brain is nervous (or mental) excitement. It is the efferent or motor reaction (always in their continuity with the afferent process) in which these excitements discharge in virtue of which we apprehend the qualities of external things."[56]

Dr. M. J. Piaget emphasizes the importance of motor response in the development of intelligence. There are, according to him, three levels of mental activity of the child. The first is the "intelligence motrice," which occurs before or independent of language. There is a progressive accommodation of the organism to the objects of the environment due to the motor patterns and a reciprocal adaptation of the object to the organism, as when weight is felt as a force. The child is, however, ignorant of the real meaning of the motor activity. There is no active control, merely a passive acceptance. In the further development of the child there occurs the second level, egocentric thought and lastly rational thought.[57]

In Germany Dr. L. Grünhut has recently, in answer to the Gestalt theory, contended that we perceive form by running our eyes over the given visual stimuli. We do not merely open our eyes for possible sensations, but rather create our perception by allowing our eyes to wander over the object. We do not see isolated points, but through this active process we perceive a unity in a given manifold. In other words, he explains that the picture on the retina and the afferent impulses are not yet a perception. It is only through response that discrete points in space are formed into a coordinated whole.[58] In an article which has appeared this year, Professor F. M. Gregg

[49] R. Müller-Freienfels, "Das Denken und die Phantasie," p. 10, Leipzig, Barth, 1916.

[50] E. Posch, "Umriss einer realistischen Psychologie," p. 205.

[51] J. F. Dashiell, "Is the Cerebrum the Seat of Thinking?" *Psychol. Rev.*, 33, p. 18, 1926.

[52] *Ibid.*, p. 25.

[53] H. Friedländer, "Die Wahrnehmung der Schwere," *Zsch. f. Psychol.*, 1920, 83, p. 135. See also my article, "A Response Interpretation of Consciousness," p. 98.

[54] D. Katz, "Der Aufbau der Tastwelt," *Zsch. f. Psychol.*, Ergänzungs bd., 11, p. 260, 1925.

[55] S. Alexander, "Art and the Material," p. 19, New York, Longmans, 1925.

[56] *Ibid.*, pp. 20–21.

[57] M. J. Piaget, "Les trois Systemes de la Pensée de L'Enfant," *Bull. Soc. fr. de Phil.*, 28, p. 100, 1928.

[58] E. Jaensch and L. Grünhut, "Über Gestalt Psychologie und Gestalt Theorie," *Mann's Pädagogisches Magazin*, No. 1262, p. 134, 1929.

also applies the motor theory to explain certain of the phenomena which have interested the Gestalt psychologists.[59]

Professor M. Ponzo has expressed his general view in the statement that there is not only a concomitance of motor phenomena and mental states, but an invariable participation of motor response in all forms of mental activity.[60] He has described the rôle of response in his account of the experimental work of the Turin laboratory. Several of his examples are the following: Illusions of size of objects occur through changes in the motor response;[61] we understand better what is said by internal repetition or murmur of the words,[62] an observation which was also made some time previously by O. Jespersen;[63] each individual expresses himself in motor terms in a fashion as characteristic as are certain of his anatomical features.[64]

Finally, we have a successful attempt by Dr. E. Jacobson to detect directly the muscular response during mental activity by means of the action potentials. He found that the action patterns during silent thought correspond to those obtained when the words were actually spoken. He concludes that "during imagination, recollection and concrete or abstract thinking involving words or numbers, muscular contractions characteristically appear as specific components of the physiologic process of mental activity."[65]

We have seen from this brief historical sketch that the rôle of motor response in consciousness has been emphasized by many thinkers throughout the centuries, either directly or by suggestion through the reference to kinesthesis. Much of the discussion has been theoretical, or at best what Titchener after Brentano has termed empirical, but this is true of most of the fundamental theories of psychology until the nineteenth century. Since then a number of experiments have yielded results which seem to support the theory. It is fair to predict that in the future there will be less theorizing and more research of a nature similar to that of Jacobson. The theory itself must wait upon further experimental findings for its development and more precise refinement.

OBITUARY

JOHN BELLING

JOHN BELLING died on February 28, 1933, in San Francisco. He was born at Aldershot, England, on October 7, 1866, and taught in private and public schools in England, taking instruction meanwhile at London and Birmingham. In the university at the former place he received the degree of bachelor of science. In later life he was given the honorary degree of doctor of science by the University of Maine in 1922.

He lectured in the Horticultural College at Swanley, England, and later at Llandidloes, Wales, in 1900–01. Shortly after this he migrated to the British West Indies, where he became investigator in the Department of Agriculture. In 1907 he came to the Florida Experiment Station as assistant botanist and published important researches there on hybrid beans.

Shortly after the war he came to the Carnegie Institution of Washington as cytologist in the department of genetics, and was associated with Dr. A. F. Blakeslee in the investigation of the chromosomes of Datura. Here his genius in microscopy and his philosophic insight opened up a new field in the study of the behavior of chromosomes and in the interchange of segments between non-homologous chromosomes. Belling was subject to periods of depression during which he did some of his most brilliant work. Believing that it was important for him to have a change of scene he was transferred by the institution to Berkeley, California, where he worked in a corner of Professor E. B. Babcock's laboratory, continuing his fundamental researches on the structure of chromosomes in hyacinths and various lilies. In these investigations, under superlative technique, he believed he was able to see structures, which on account of their number and size, he identified with genes.

Belling was the author of a book on the use of the microscope, which has been eminently successful. A book on the study of the chromosomes has been written, but not published. After the sixth International Congress of Genetics, held in Ithaca last summer, a number of foreign delegates traveled to Berkeley to examine Belling's preparations showing the structure of the chromosomes, and to discuss with him his interpretations of them.

He married Miss Hannah Sewall, who died in 1926

[59] F. M. Gregg, "Materializing the Ghost of Köhler's Gestalt Psychology," *Psychol. Rev.*, 39, 257–270, 1932.

[60] M. Ponzo, "Principes et Facteurs du Dynamism psychologie dans les Recherches de l'Ecole de Psychologie de Turin," *Jour. de Psychol.*, 27, p. 617, 1930.

[61] *Ibid.*, p. 630.

[62] *Ibid.*, p. 624.

[63] O. Jespersen, "Lehrbuch der Phonetik," p. 6, 2te aufl., Leipzig, Tuebner, 1913.

[64] M. Ponzo, *loc. cit.*, p. 641.

[65] E. Jacobson, "Electrical Measurements of Neuromuscular States during Mental Activities," vii, "Imagination, Recollection and Abstract Thinking Involving the Speech Musculature," *Amer. Jour. Physiol.*, 97, p. 209, 1931.

without issue. He is survived by a brother, James Belling, of Cornwall, England.

CHARLES B. DAVENPORT

RECENT DEATHS

EDWARD BRUCE WILLIAMSON, research associate in the Museum of Zoology, University of Michigan, died on February 28, at the age of fifty-five years.

DR. H. GREGG SMITH, associate in biochemistry at the State University of Iowa, died on February 26. He was thirty-four years old.

NATURE reports the deaths of Professor Johan van Baren, an authority on soil mineralogy, professor of geology and mineralogy in the Agricultural University of Wageningen, Holland, on February 7, aged fifty-seven years, and of Lieutenant-Colonel J. C. G. Kunhardt, formerly of the Indian Medical Service, who did valuable work on plague prevention in India and also in the advancement of the rubber industry, at the age of fifty-seven years.

SCIENTIFIC EVENTS

THE FACULTY OF MEDICINE OF PARIS

A CORRESPONDENT of the *Journal* of the American Medical Association writes that the Faculty of Medicine of Paris, having often complained of its cramped quarters, which in view of the constantly increasing number of students have became inadequate, received from the Rockefeller Foundation the offer of a gift of $6,000,000 for new buildings for the faculty of medicine, on condition that the French government furnish an equal sum. It was impossible to erect the new buildings on the present site along the Boulevard St. Germain, in the center of Paris, where real estate commands an enormous price. When a different site was sought, consideration was given to the site occupied by the Halle-aux-vins, on the bank of the Seine farther to the east. The Halle-aux-vins in that case would have been moved outside the city. The wine merchants refused to move. Attention was then given to a large unoccupied area south of the city, which was being used for a military aviation school. The suggestion of this site brought protests from the professors, students, medical libraries and the dealers in surgical instruments that had been grouped for centuries about the present buildings. This site was several miles away from the principal teaching hospitals. Attention was then given to a tract occupied by the Ste. Anne psychopathic hospital, located to the south in the vicinity of the University City. It was not long before protests were heard. Professors think the location is still too remote, and their opinion is shared by the merchants. Furthermore, it would be necessary to rebuild a much larger psychopathic hospital elsewhere; for it is now inadequate, owing to the increasing number of insane persons. The council of the faculty of medicine, according to the correspondent, is placed in an embarrassing position by the gift of the Rockefeller Foundation, especially in view of the state of the French treasury. The present buildings of the faculty of medicine are only fifty years old, and it would suffice to add further stories or erect annexes. In short, the council appears disposed to postpone until more propitious times the realization of the generous proposal of the great American philanthropist. Attention has been called also to the fact that the magnificent university buildings erected with the same aid but located too far from the center of the city are already revealing grave disadvantages by reason of their remoteness. The students are attending their lectures less regularly on account of the time required to go to and fro.

REVISION OF THE INTERNATIONAL ELECTRICAL UNITS

THE Bureau of Standards reports that the third biennial meeting of the advisory committee on electricity and photometry established by the International Committee on Weights and Measures opened on January 31 at the International Bureau of Weights and Measures, at Sevres, near Paris.

The international committee has undertaken to revise the present international electrical units. It proposes to base the units directly upon absolute measurements in the electromagnetic centimeter-gram-second system, instead of defining them by means of the mercury-ohm tube and the silver voltameter. Redeterminations of the ohm and ampère by absolute measurements are in progress in several national standardizing laboratories, including the Bureau of Standards; at the meeting at which the bureau was represented by E. C. Crittenden, chief of the Electrical Division, plans were made for comparing the results found in different countries and for furnishing to all countries standards based upon the combined results.

The international committee likewise hopes to establish uniform units and standards throughout the world for the measurement of light. In this attempt it is collaborating with the International Commission on Illumination. A special committee on units and standards appointed by the latter commission, and consisting of representatives of France, Germany, Great Britain, Japan, the Netherlands and the United States, met in Paris on January 30 to prepare recom-

mendations on photometry for the official advisory committee.

The bureau has proposed the establishment of a system of photometric units based primarily upon the intensity of the light given by a "black body" radiator at the freezing point of platinum. The adoption of such a basic unit must be supplemented by agreement upon a method for measuring lights differing from that of the basic standard in color. The flicker photometer, with proper allowance for the characteristics of individual observers, affords one of the most simple and practical methods for making such measurements. Its use has, however, not been viewed with favor abroad. Consequently, a basis for international agreement is being sought in spectrophotometric measurements of colored filters, from which standard values for transmission of visible light can be calculated by means of "visibility factors" which have already been accepted by the International Commission on Illumination.

In both of these projects the National Physical Laboratory of Great Britain and the Bureau of Standards have been cooperating. Mr. Crittenden therefore visited London on his way to Paris in order to compare experimental results found at the bureau with those of the British laboratory. These two laboratories have joined in proposing that the new units in electricity and in light be put into general use on January 1, 1935. An alternative proposal is that their introduction be deferred until 1937. The most important duties of the 1933 meeting are to choose between these dates and to agree upon a definite schedule for carrying out the series of comparisons and interchange of standards which will be necessary.

THE PRIESTLEY LECTURES AT THE PENNSYLVANIA STATE COLLEGE

THE seventh annual Priestley Lectures at the Pennsylvania State College will be given at 7:30 P. M., on April 3, 4, 5, 6 and 7.

Two memorials to Joseph Priestley have been established by the faculty and alumni of the department of chemistry: 1. In 1919 the alumni of the department purchased the old Priestley residence at Northumberland, Pennsylvania, about seventy miles from the college. They have built near the house a museum to hold such Priestley relics as can be gathered together. The alumni have assumed responsibility for the maintenance of the whole property in recognition of Joseph Priestley's contributions to early American chemistry. 2. An annual series of lectures was inaugurated by members of the faculty in 1926, bearing the name of the Priestley Lectures. These lectures deal each year with the border-line between physical chemistry and some other branch of science.

In 1931, Phi Lambda Upsilon (honorary chemical fraternity) undertook the financial support of the Priestley Lectures. These lectures, therefore, now constitute a joint memorial to Joseph Priestley on the part of both the faculty of the Department of Chemistry and the Honorary Fraternity of Phi Lambda Upsilon.

This year's lectures deal with the border-line between physical chemistry and metallurgy. They will be given by Professor Eric R. Jette, of the School of Mines of Columbia University.

The former Priestley Lectures are as follows:

The first year's lectures dealt with the border-line between physical chemistry and biocolloids. They were given by V. Cofman, of the Experimental Station of E. I. Du Pont de Nemours and Company.

The second year's lectures dealt with the border-line between physical chemistry and metallography. They were given by Dr. S. L. Hoyt, of the Research Laboratory of the General Electric Company.

The third year's lectures dealt with the border-line between physical chemistry and medicine. They were given by Dr. H. B. Williams, head of the department of physiology of the College of Physicians and Surgeons, Columbia University.

The fourth year's lectures dealt with the border-line between physical chemistry and ceramics. They were given by Dr. Louis Navias, of the Research Laboratory of the General Electric Company.

The fifth year's lectures dealt with the borderline between physical chemistry and electrical engineering. They were given by Dr. John W. Williams, assistant professor of chemistry at the University of Wisconsin.

The sixth year's lectures dealt with the border-line between physical chemistry and biological chemistry. They were given by Dr. Victor K. LaMer, associate professor of chemistry of Columbia University.

THE SIXTEENTH SESSION OF THE INTERNATIONAL GEOLOGICAL CONGRESS

THE International Geological Congress will hold its sixteenth session in Washington, D. C., from July 22 to 29.

The project of holding an International Geological Congress originated in connection with the Centennial Exposition of 1876 at Philadelphia. A Founders' Committee was formed in that year with James Hall, state geologist of New York and one of America's foremost geologists, as its president. The committee included T. Sterry Hunt, of Canada, as secretary, six other members from the United States and Canada, and one each from England, Sweden and Holland. Thomas Henry Huxley was the member from England. This committee asked the Geological Society of France to cooperate in preparing for a congress at the Paris Exposition in 1878 and the French society appointed an organization committee on July 27, 1877.

This meeting was the first of a series of fifteen congresses that have been held as a rule at intervals of from three to four years, in various countries of Europe and in Mexico (1906), Canada (1913), and the United States (1891). The preceding one was held in South Africa in 1929.

The International Geological Congress is regarded as a continuing organization for which the responsibility is passed on from the organization committee of one session to that of the next. Attempts have been made at various times to induce the congress to form an International Union or to affiliate with the International Research Council, but the preference of the members has been in favor of the more informal organization that has always existed.

However, the thirteenth session which met in Brussels in 1922 adopted a set of statutes consisting of twelve articles, which were essentially a formulation of the traditional practises of the congress and which were for the most part very general in character.

In general the meetings of the congress are financed by contributions from governments, organizations and individuals. The coming session was financed, in its early stages, by contributions from members of the organization committee. Subsequently, however, the Geological Society of America undertook to pay the expenses of organizing the congress, and has offered a liberal subsidy to reduce the cost of the excursions to participants.

One of the principal objects of the International Geological Congresses is to enable geologists to acquaint themselves, by personal observation, with some of the most significant and distinctive features of the geology of the country in which the congress is held. For this reason it is customary for the organizers of each congress to carefully plan and prepare a number of excursions to take place before and after the scientific sessions. On each excursion a special type of geology generally predominates. The nature of some of the excursions to be given in connection with the coming congress in Washington is indicated by the following summary descriptions of them:

Eastern New York and Western New England.
Mining districts of Southeastern and Central States.
Appalachian Valley in Virginia.
Paleozoic stratigraphy of New York.
Coastal plain of the Chesapeake Bay region.
Oil fields of Oklahoma and Texas.
Geomorphology of the central Appalachians.
Mineral deposits of New Jersey and eastern Pennsylvania.
Transcontinental excursion starting from San Francisco.

These excursions will take place before the sessions in Washington and last from 4 to 12 days. In addition, a committee of New York geologists has arranged a group of one and two day excursions in the vicinity of New York for those who do not care for the longer trips. There will also be short excursions from Washington during the session.

After the Washington sessions there will be two transcontinental excursions, each lasting thirty-one days. These will include a wide range of geologic features with some choice of side trips. There will also be two shorter excursions after the congress, one for glacial geology and one to study the iron and copper deposits and the pre-Cambrian geology of the Lake Superior region.

In the minds of the founders of the congress one of its principal functions seems to have been to bring geologists together so that they could standardize by international agreement certain methods and ideas. This is clearly formulated by the president of the Organization Committee of the first congress in his address of welcome where he says, "The dominant motif in organizing this congress has been the need, felt by all, of mutual agreement on geologic classification and nomenclature," though he goes on to say "We can not invoke here the law of numbers; no majority can impose convictions which the sense of truth alone can bring about." The inherent limitations to such activity in a rapidly growing science, except as regards the standardization of cartographic symbols, has become increasingly clear with successive congresses, so that the tendency has been more and more away from standardization and towards exchange of ideas.

Thus, out of the program of the first Congress which consisted of the following topics:

1. Standardization of geologic publications from the point of view of nomenclature and symbols.
2. Discussion of various questions relating to the limits and characters of some formations.
3. Representation and coordination of alignment features (faults and veins).
4. Relative value of faunas and floras from the point of view of the delimitation of formations.
5. Value of mineralogic composition and texture of rocks from the point of view of their origin and age.

two lines of activity have developed, one represented by the program of topics for discussion, the other by the commissions for organizing the knowledge in certain fields and increasing international agreement in them.

As a result of this development the organization committee of the sixteenth session has proposed the following topics for special discussion at the coming meeting:

Measurement of geologic time by any method.
Batholiths and related intrusives.
Zonal relations of metalliferous deposits.
Major divisions of the Paleozoic era.
Geomorphogenic processes in arid regions and their resulting forms and products.
Fossil man and contemporary faunas.
Orogenesis.
Geology of petroleum.
Copper resources of the world.

In proposing for discussion such a topic, for instance, as "Major Divisions of the Paleozoic Era" it is hoped that as a result of the formal papers presented and the discussion that accompanies them, a closer approach to agreement in this very controversial field will be reached; but there will be no attempt to formulate certain conclusions as representing the opinion of the congress as a whole.

The international commissions of the congress appointed at any session carry over to the next session, at which they are expected to present their reports. They may be and many of them have been continued from session to session. Those appointed at the fifteenth session are:

1. Spendiaroff prize.
2. Palaeontologia Universalis.
3. Lexicon of Stratigraphy.
4. Glaciers.
5. Fossil Man.
6. Crust of the earth.
7. Geophysics and Geothermics.
8. Map of Europe.
9. Map of the Earth.
10. Distribution of the Karroo (Gondwana) system.
11. International Map of Africa.
12. Sub-Commission of African Surveys.

The success of several of these which are charged with the preparation of definite publications depends largely on funds from outside sources. The Prussian Geological Survey, under the auspices of the committees of the International Geological Congress, has supervised the compilation of the geologic maps of Europe and of the World, which have been published and are sold through regular publishers.

Other commissions have fostered work in the fields with which they were concerned or provided for the publication of results in current journals. There are obvious difficulties in the way of effective action by a commission whose members are scattered over the entire earth, as is the case with most of these commissions. However, even when they can not produce definite results they promote international agreement in the fields with which they deal.

The organization committee of the eleventh session held in Sweden in 1910 decided that it was desirable for the congress to exert a more extensive and systematic influence on the development of applied geology. They, therefore, published a volume on "The Iron Ore Resources of the World." It has been the practise of the organization committee of most congresses since then to prepare a similar volume on the resources in some major mineral deposit. Volumes on coal, phosphate and pyrite, and gold have been published by previous congresses and the organization committee of the sixteenth session is preparing one on copper.

These volumes aim to describe the geology of deposits all over the world and as far as possible to estimate reserves. They have been found very valuable by those concerned with the mineral industries and have probably helped to secure financial support for the congress.

Not the least valuable function of these congresses, as of all gatherings of scientists, is to bring about personal acquaintance and friendship among those who attend and to afford opportunity for informal discussion. During the scientific sessions of the International Geological Congresses some formal entertainments as well as informal gatherings of groups and individuals provide for this, but the best opportunity is afforded by the excursions, on which the participants are constantly together for a number of days, and discuss many of their problems with the evidence before them.

Any one may become a member of the Congress For information address General Secretary, International Geological Congress, U. S. Geological Survey, Washington, D. C.

M. I. G.

SCIENTIFIC NOTES AND NEWS

DR. ROBERT F. GRIGGS, professor of botany at George Washington University, Washington, D. C., has been elected president of the Washington Academy of Sciences.

GEORGE W. FULLER, of Fuller and McClintock, New York, has been elected chairman of the Engineering Foundation. He succeeds H. Hobart Porter, president of the American Water Works and Electric Company.

DR. SYDNEY CHAPMAN, chief professor of mathematics at the Imperial College, South Kensington, has been made president for 1933 of the Royal Meteorological Society.

CONRAD BECK, director of R. and J. Beck, sci-

entific instrument manufacturers, London, has been elected president of the Royal Microscopical Society.

THE degree of doctor of science will be conferred by the University of Dublin on Professor William Lawrence Bragg, professor of physics, Victoria University of Manchester, and on Professor John Scott Haldane, fellow of New College, Oxford, honorary professor and director of the Mining Research Laboratory, Birmingham University.

DR. EMIL ABDERHALDEN, professor of physiology at Halle, has been elected an associate member of the Society of Biology at Paris.

A TESTIMONIAL dinner to Professor Charles W. Ballard, of the faculty of the Columbia College of Pharmacy, was tendered to him by the Pharmacy Alumni Association on March 9. Professor Ballard has been associated with the College of Pharmacy for twenty-five years. Among the speakers were Dean Henry V. Arny, Dean Emeritus H. H. Rusby, Professor Marston T. Bogert, Columbia University, and Edward Bocker, the New York City Department of Health.

JOHN J. KELEHER, a member of the staff of the New York Aquarium, has been awarded the gold medal of the New York Zoological Society in recognition of his thirty years' service. The presentation was made by Dr. Charles H. Townsend, director of the aquarium, who himself completed thirty years with the institution last November.

IN recognition of their outstanding contributions to medicine, thirteen leading physicians and research workers from ten nations have been elected to honorary fellowship in the New York Academy of Medicine. The number of honorary fellows is limited to fifty; at present there are thirty-five. The new fellows are: Charles Achard, professor of the Faculté de Médecine of Paris and permanent general secretary of the Académie de Médecine; Roberto Alessandri, formerly professor of surgical anatomy, now director of the surgical clinic at the University of Rome; Sir Charles Ballance, consulting physician at St. Thomas's Hospital and National Hospital for Paralysis and Epilepsy, London; Frederick Grant Banting, professor of medical research at the University of Toronto; Sir Henry Hallett Dale, secretary of the Royal Society and director of the National Institute for Medical Research, London; Otfried Foerster, professor of psychiatry and neurology, Breslau; Carl Gustaf Forssell, professor of radiology in the Medico-Chirurgical Institute and director of radiumhemmet, Stockholm; James Bryan Herrick, emeritus professor of medicine, Rush Medical College, Chicago; Cornelius Ubbo Ariens Kappers, professor of comparative anatomy of the nervous system at the University of Amsterdam; George Richards Minot, professor of medicine, Harvard University; William Gibson Spiller, professor of neurology at the University of Pennsylvania and consulting neurologist at the Philadelphia General Hospital; Alfred Vogt, professor of ophthalmology at the University of Zurich, and Karel Frederik Wenckebach, professor of medical pathology and therapy at the University of Vienna.

PROFESSOR B. NĚMEC, director of the Institute of Plant Physiology of the Charles University, Prague, Czechoslovakia, will celebrate his sixtieth birthday on March 12. A correspondent writes: "Professor Němec is a prominent plant physiologist, working on experimental cytology, caryology, anatomy, experimental morphology, physiology of fecundation, symbiosis, parasitism, plant pathology and regeneration. His 'statolit' theory is well known, as are his recent discoveries of artificially induced mixoploidy and polyploidy in plants by means of chloral hydrate. These discoveries were discussed by him at the fifth International Botanical Congress held at Ithaca in 1926. Professor Němec is a corresponding member of the American Botanical Society, and of many other learned societies, Czechoslovak and foreign. He is the president of the American Institute in Prague. Professor Němec took an active part in the work which resulted in the liberation of his country. He is now a representative of the National Democratic Party in the Parliament and is, at the same time, one of the most prominent members of Charles University."

ON the recommendation of Dr. Gregory and Dr. Sherwood, of the American Museum of Natural History, the executive committee of that institution has appointed Dr. William Beebe a member of the department of ichthyology, with the title of research associate in oceanography.

DR. SAMUEL E. POND has resigned from the University of Pennsylvania, where he has been assistant professor of physiology in the Schools of Medicine and Dentistry, to accept the position of technical manager at the Marine Biological Laboratory, Woods Hole, Massachusetts. Dr. Pond will be in residence in Woods Hole throughout the year, beginning on April 1. In addition to the direction of laboratory matters of a technical nature he will continue his researches on elementary calcification and the solid phases in ossified tissues.

DR. GEORGE KREEZER has resigned as Merriam research fellow at Cornell University to become research associate at the Training School at Vineland, New Jersey. This appointment was made possible by a gift recently made by friends of the Vineland Laboratory. It is anticipated that Dr. Kreezer will con-

duct a series of investigations of birth-injured children by the methods of physiological psychology.

F. S. BRACKETT has retired from the directorship of the Division of Radiation and Organisms of the Smithsonian Institution and becomes research and consulting physicist. Dr. C. G. Abbot, secretary of the institution, has assumed the directorship of the division and E. S. Johnston has become assistant director.

PROFESSOR JAMES H. BREASTED, of the Oriental Institute, University of Chicago, sailed from New York on February 4 for an inspection of field work in Persia.

DR. MORRIS S. VITELES, assistant professor of psychology at the University of Pennsylvania and director of personnel research in the Philadelphia Electric Company, has been elected a member of the board of directors of the Personnel Research Foundation.

DR. THOMAS STOCKHAM BAKER, president of the Carnegie Institute of Technology, Pittsburgh, who has been lecturing in Germany under the auspices of the Carl Schurz Society, arrived in New York on March 3.

DR. H. H. DONALDSON, of the Wistar Institute of Anatomy, addressed the Sigma Xi Society at the University of Pittsburgh on February 15 on "What We have Learned on the Growth of the Brain during the Past Forty Years."

DR. ANNIE J. CANNON, of the Harvard College Observatory, gave on February 15 an address on "Eclipsing Experiences" before the science seminar of the University of Maine.

DR. BAILEY K. ASHFORD, colonel, U. S. Army Medical Corps, retired, professor of mycology in the School of Tropical Medicine, San Juan, Puerto Rico, discussed acute uncinariasis at the Research Club of the department of medical zoology of the Johns Hopkins University School of Hygiene and Public Health on February 20. His discussion was based on case histories of individuals who came to his attention almost immediately after receiving exceedingly heavy infestations of *Ancylostoma duodenale* while wading in infected water in Puerto Rico.

RECENT visiting lecturers to the department of geology and geography, Northwestern University, and their subjects included: T. A. Hendricks, of the U. S. Geological Survey, "The Classification of Coal"; L. E. Workman, of the Illinois Geological Survey, "Subsurface Methods as Applied to Illinois"; C. W. Washburne, consulting geologist, "Structural Studies in the Oregon Coast Ranges"; Dr. G. R. Mansfield, of the U. S. Geological Survey, "Viewpoints in Geological Research"; Professor E. S. Bastin, of the University of Chicago, "Ores of Copper Lean in Iron and Sulphur."

THE fourth lecture to the faculty and students of the School of Medicine, The George Washington University, on the Smith-Reed-Russell Society series was given on February 23 by Professor Stanhope Bayne-Jones, of the Department of Bacteriology, Yale University Medical School, and chairman of the Medical Division, National Research Council, on "Bacterial Toxins." The next lecture in this series will be given by Dr. Maurice C. Hall, chief of the Zoological Division, Bureau of Animal Industry, U. S. Department of Agriculture, on March 16, on "Drama Anthelmintica." The regular faculty seminar for February was given by Professor George B. Jenkins, of the department of anatomy, who spoke on "Comparative Embryology of the Central Nervous System."

A GIFT of $100,000 for the general purposes of the Gray Herbarium of Harvard University has been received from Earl Willson Bemis, of Worcester, Massachusetts. The original collection was founded by the late Asa Gray and given by him to the university in 1864.

A GIFT has been made by E. R. Squibb and Son, New York, through the National Research Council Committee on Drug Addiction, of a fellowship of $700 for work in pharmacology to be carried on under the direction of Professor C. W. Edmunds, in the Medical School of the University of Michigan.

PLUTARCO ELIAS CALLES, of Mexico, has turned over his Santa Barbara hacienda to the Agricultural Department to be used as an experimental station.

THE Prussian Ministry of Public Instruction has granted permission to the various clinics, institutes and the like, to announce the maximum number of students that, in their opinion, can receive proper training and to reject the applications of students in excess of that number. In the dental institutes, such restrictions were introduced some time ago.

UNDER an amendment of the United States patent statute approved by the President May 23, 1930, which authorizes the issuance of patents to inventors or discoverers of distinct and new varieties of asexually propagated plants other than tuber-propagated plants, 39 plant patents had been issued by the United States Patent Office up to the end of October, 1932. The administration of the law is vested in the commissioner of patents, but, as provided for in the law, the Secretary of Agriculture is charged with the duty of determining for the commissioner of patents, upon his request, whether varieties for which patent applications are made are in fact distinct and new. The special researches necessary to such determinations for

the information of the Commissioner of Patents are assigned to the chief of the Bureau of Plant Industry to carry out. "A plant patent," according to Dr. W. A. Taylor, chief of the Bureau of Plant Industry, "grants to the patentee the exclusive right to use, vend and asexually reproduce the new variety covered by the patent throughout the United States and Territories for seventeen years. Naturally, under the limitations prescribed in the statute, most of the alleged new varieties thus far considered are in the horticultural field, relatively few general field crops other than tubers being capable of asexual propagation on a commercial scale in temperate climates. The granting of a patent on a new variety in no way passes on its adaptability to climatic conditions or for special uses or on its economic value, nor does it determine the validity or otherwise of any varietal name which may be applied to the variety by the originator or disseminator.

THE London correspondent of the *Journal* of the American Medical Association writes: "It is striking that in the present period of industrial depression and unemployment, unprecedented both in intensity and in duration, the general health of the population has been remarkably good and has even improved. The registrar-general's statistical review for 1931, which has just been published, shows a death rate of 12.3 per thousand persons living, 0.9 above that for 1930. That rate, however, was the lowest ever recorded, largely because of the exceptionally mild weather in the early part of the year, when the greatest number of deaths occur. The higher rate for 1931 is a reflection of the more severe weather of the early part of the year. Infant mortality was similarly affected, the deaths of children under 1 year being 66 per thousand live births, against 60 in 1930. That year and 1928, however, are the only years that have shown a lower mortality than 1931. The death rate for cancer was 1,484 per million persons living, against 1,454 in 1930. But if allowance is made for the difference in the age constitution of the population (which is constantly becoming greater) the increase in the cancer rate becomes much smaller. Tuberculosis again furnished a new low record, 896 deaths per million living. Road accidents due to mechanical vehicles caused 5,892 deaths. The figures for the preceding four years were 4,452, 5,196, 5,752 and 6,342. The decrease in 1931 is the first that has occurred since 1921, the figures having steadily increased previously. The birth rate was 15.8 per thousand persons living, the lowest on record and 0.5 below that for 1929 and 1930."

DISCUSSION

UNIVERSITY PATENTS

NOTHING seems at first sight more reasonable and effective to provide funds for research work in colleges, universities and research institutions than the exploitation, under the protection of patent laws, of the results of research work. Apparently in increasing numbers the universities in this country are resorting to patenting—directly or through approved agencies—for the stated purpose of obtaining money to support research work done by members of their staffs.

Arguments in favor of such a policy seem to have been published rather more fully than other types of comment. Experience, however, is proving that this policy of patenting, so attractive when first contemplated, involves more numerous and more serious difficulties than were at first foreseen, even by those who opposed the policy on ethical grounds. It is not with the ethical or moral validity of universities exploiting patents for revenue that the present communication deals. I wish to call attention only to some of the problems entailed by the policy, at present spreading among universities in the United States and Canada, of taking or being party to the taking of patents for the purpose of obtaining revenue for research work to be done by their students or staff. If explicit definition can obviate misunderstanding it may be well to observe that it is patenting for revenue and not patenting to prevent exploitation by others which is under consideration. I bring forward the matter because, now that the advantages of this policy have been published, it seems reasonable to point out some of the disadvantages.

A professor in one of our large state universities visited not long ago a university whose declared policy it is to take out patents where possible for the research work of its personnel. The professor talked with a young staff member about his research work. It became apparent that what the professor had learned from his own research work would lead, if pieced together with what the young man had found out, to a distinct advance in knowledge, an advance very probably capable of being patented. Although the young man would have been delighted to have had an honorable part in an advance of knowledge and might have received a merited recognition for his share therein, and although science might have been advanced, the professor kept his mouth shut because he couldn't see why his work should be an integral part of a patent controlled for the exclusive benefit of another university. Perhaps it would be better if both universities went in for the patent business. Then the professor wouldn't have felt so resentful or

so much at a disadvantage. He would have magnanimously given the young man his big chance by telling him what he needed to know. But of course there is just the possibility that another man would have kept silence, gone back to his own laboratory to confirm the young man's findings and purloined the patent not for his personal advantage of course but for his university. In such a case the young man, if he were as intelligent as he is educated, would learn to keep his mouth shut. I cite this little story from real life because it is such a nice illustration of what patenting for money has done in this instance to the advance of knowledge—for which, incidentally, the two states' funds are being in part devoted.

Some time ago in a well-known medical school a certain synthetic antiseptic was on trial clinically. The first reports were almost as brilliant as the color of the substance itself. The opportunity to patent the antiseptic would have meant an income for research of perhaps $100,000 a year. This entrancing possibility was not seized. Instead of that the clinicians of that school, devoid of proprietary interest, maintained a critical attitude and pursued their investigations, during which the earlier (and honest) enthusiasms paled because the stuff wasn't as good as they thought at first. As the dean remarked to me later, "Would we have cared to examine it as critically if it might mean the loss of a big income for our research work?" For politeness' sake one should quench such doubt by assurances that of course they would, or at least they wouldn't have taken out the patent until they knew that further investigation could not qualify their confidence.

In the dairy state of Ubique I know of an owner of a large milk products company. He is angry because the University of Ubique Research Associates, Incorporated, has taken out a patent for a process that could improve the nutritional value of certain milk products. He says: "I pay taxes to support the State University and its research workers, and as soon as they find something of use to me I have to pay them again for being successful. I'll be ——ed if they can have it coming and going. I'll bring counter suit if they try to sue me."

It is obvious that obtaining a patent is not complete protection. Some money has to be set aside to put teeth in it, *i.e.*, to punish infringements. Without the aid of newspaper files many medical scientists can recall a trial which is reported to have cost the defendants $80,000. Duly skeptical of such a figure, I should, however, assume that the patentees did not use all their takings that year for research. Shortly after the trial they were told by a spirited chief of one city health service that he was going to use their process anyhow and on a large scale, for which he proposed to pay them just one dollar and if they wanted to refuse this offer and bring suit, maybe they'd win, but the city was rich and had good lawyers.

When the patentees set aside large sums for the prosecution of infringements instead of the prosecution of research, there is no assurance of good feeling in the scientific or academic worlds. A well-known American patent for the treatment of an important infectious disease is protected in one country abroad by a clause which forbids its use in research directed to its improvement. An entirely honorable research organization in that country on consulting legal advice as to the probable consequences of using the material for research purposes was told that they would probably be supported by the courts but that the trial would cost upwards of $15,000. Having no funds to fight for the legal right to do research work they have left that field where the patentee desires it to be left. The only consolation that could be offered to them is that their research staff will be spared the waste of time upon the witness stand—a waste of time which has disgusted at least one scientist in this country to the point of deserting a field in which lawsuits may require his time.

The dean of one of our larger medical schools complains that one of his teachers is so busy controlling the product made under a patent held by the university that there is no time left for research or teaching. As a university interest it can't be disregarded, since there may be some money in it, so a competent investigator is now busy testing a commercial product. As long as there is a chance of the product being improved by some one else, he is likely to be tied down for some time to this one subject.

In justice to the universities now in the patent business, it should be admitted that no case has yet come to common knowledge of an appointment or promotion being accorded to a man because his mind runs to patentable and consequently profitable research. Surprise at such an event would, however, be a trifle naïve when the universities intentionally and officially encourage patents for revenue to support the research expenses they so badly need.

One neither moralizes nor speculates in restating the present tendency as being an assertion on the part of certain universities that they are disposed to encourage the means to extract legally and certainly from the public in this and other countries a contribution to their own research work, which is as they believe inadequately supported. They invoke the patent law to supplement what public appreciation fails to provide: they insist on a general and immediate contribution to maintain research which they can not guarantee will be of value equal to its cost. An

excuse is provided for the first time for the public to leave research in the universities to "look out for itself."

I am not interested in discussing here the ethics or morality of the matter. The way it is working out is proving dangerous: it tends to shut off unselfish exchange of ideas and information, it tends to kill a critical and impartial attitude, it tends to introduce quarrels and bitterness and to consume time and funds in lawsuits. It may quite naturally influence the choice of university personnel and the choice of research problems. If, in addition, the policy of taking out patents for revenue be interpreted as a declaration of independence the public may quite cheerfully acquiesce and leave research work to earn its own way. Why should gifts intended for the general welfare play the rôle of capitalizing a business? And what becomes of the peculiar function of university research as contrasted with that of the shrewdly administered business enterprise?

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THE COEFFICIENT OF CORRELATION

IN a recent article describing a least-square curve fitting machine[1] the authors make use of the Pearson product-moment coefficient of correlation to test the agreement of the parameters obtained by use of this device with those obtained by an algebraic method. This use of the correlation coefficient to test the agreement of two methods of measuring the same quantity is frequently seen in the literature, but the soundness of the procedure is open to question.

The idea of correlation as conceived by Galton implies that there is such a measurable quantity as *degree of relationship,* and the coefficient developed by Pearson is taken to give this measure. In keeping with this idea it is argued that if two methods of measurement agree well, their results will be "closely related" and *vice versa;* hence the use of the coefficient. As a matter of fact, the correlation coefficient is more correctly understood, specifically as a particular parameter obtained in a least-square fit of a straight line to the data correlated, and its significance is not general, but varies with the character of the data to which the fit applies.

In the case at hand, it can easily be shown that the coefficient measures, in large part, something quite different from what is intended. The method of procedure when two instruments or methods of measurements are to be compared is as follows: A series of determinations over the entire range of instrument or method x is made, and upon the same data determinations are made with instrument y. The corresponding measurements are then correlated. The coefficient may be given by

$$r=\sqrt{1-\frac{\sigma_{x.y}^2}{\sigma_x^2}}$$

Where r is the coefficient, σ_x is the standard deviation of the x measurements, $\sigma_{x.y}$ is the partial standard deviation of x, for a fixed value of y. Now, in instances of this kind, the distribution of x is not generally normal, but rectangular, *i.e.,* about the same number of measurements is made at each value of x. Under these circumstances σ_x depends on the range of x, being given by $\sigma_x^2=\frac{R_x^2}{12}$ where R_x is the range of x. Consequently, r is greater the greater the range of the measurements made. That the method can easily lead to paradoxical results may be seen as follows. Suppose two instruments to be uniformly comparable over their entire ranges, one with the other. A series of measurements is made over the lower half of the range and correlated, yielding a particular value of r. The same procedure is repeated for the upper half and the same value of r is obtained, appearing to give a good check of the measure of how well the two methods agree. But if now all the data are put together as a single series, the correlation will be greater. For instance, if r was 0.5 in the first case, it would be 0.9 in the second.

This fallaciousness in the use and interpretation of the correlation coefficient creeps in in other instances than where methods of measurement are compared. For instance, it is present when a physical trait like height is correlated with age, and the age range is arbitrary. It also vitiates not a little of the use made of the coefficient by psychologists.

In passing, referring to the main topic of the article first mentioned, it may be noted that the idea of obtaining a least-square fit of a line on the principle of elastic bands stretched from the points to be fitted was mentioned at least as early as 1921 by L. J. Reed.[2]

JOSEPH BERKSON

ROCHESTER, MINNESOTA

ATTEMPT TO CONFIRM THE EXISTENCE OF A FILTRABLE CYCLE OF BACTERIA BY THE USE OF "K" MEDIUM[1]

AN attempt has been made to confirm the results of Kendall reported in the *Northwestern University Bulletin* (xxxii, 5, 1931). Complete failure with 'K' medium made by us according to his directions, was

[1] Gains and Palfrey, "A Least-Square Curve Fitting Machine," SCIENCE, 76: 472, November 18, 1932.

[2] Lowell J. Reed, "Fitting of Straight Lines," *Metron,* Vol. 1, p. 3, 1921.

[1] A detailed account of the work appears in the *Journal of Infectious Diseases,* 52: 20. 1933.

followed by experiments with 'K' powder kindly sent to us by Dr. Kendall. A protocol suggested by him, using the Rawlins strain of *B. typhosus,* was followed exactly. At least five attempts in accordance with this protocol and many more based on the first reports of the medium were made.

In connection with the 'K' medium, many difficulties were encountered; for example, no uniformity of pH from tube to tube could be attained. It also occasionally develops a spontaneous turbidity without inoculation.

In summary we may state that persistent efforts to confirm Dr. Kendall's experiments have been uniformly negative.

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MARY B. LAWRENCE

HARVARD MEDICAL SCHOOL

UNIVALENT CHROMOSOMES OF TRADESCANTIA VIRGINIANA

AN esteemed correspondent, in SCIENCE (Vol. 77, pp. 49–50), states that, in *Tradescantia virginiana,* "the apparently serially arranged, miscalled univalent chromosomes represent in reality a segmented pachytene in which the synaptic pairs are lined up, back to back." I have lately been studying the pachytene of this species, and also of *Rhoeo discolor:* and have succeeded in obtaining clear preparations. In Rhoeo, only the sub-terminal parts of the 12 chromosomes synapse; and are afterwards seen at diplotene to separate, leaving terminal junctions. Thus the 12 bodies seen in the rings appear to me to be these univalents attached at the ends. For if they were "pairs . . . back to back," there would be, I think, 6 of them. In *Tradescantia virginiana* (which is, in my opinion, rightly regarded as a tetraploid), 12 of the 24 chromosomes can be seen to have synapsed, at pachytene, with their 12 homologues; while their sub-terminal parts show synapsis between 4 chromosomes. These can be seen to separate at diplotene, except for their terminal junctions. The 24 bodies seen in rings, in chains, or singly, are, I think, the univalents. For if they were "pairs . . . back to back," there would be apparently 12 of them.

JOHN BELLING[1]

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SPECIAL CORRESPONDENCE

UNIVERSITY EXPEDITION TO STUDY THE NATIVES OF CENTRAL AUSTRALIA

IN August, 1932, an expedition to study the natives of Central Australia was organized by the Board for Anthropological Research of the University of Adelaide, in conjunction with the South Australian Museum. The expenses were chiefly met by a grant from the Rockefeller Foundation, administered through the Australian National Research Council. The situation chosen on this occasion was Mount Liebig, situated almost on the Tropic of Capricorn, 200 miles by track west of Alice Springs. The natives belonging to this portion of Central Australia have hitherto escaped contact with Europeans, save to a very superficial extent. By means of a preliminary survey by Mr. Kramer, of the Aborigines Friends Association, in whom these natives had complete confidence, over 130 aborigines, including men, women and children, were gathered together for observation. Their equilibrium had been a little disturbed by a raid from an adjacent tribe, in which 7 men had traveled 100 miles to secure two women, killing their common husbands and one of the women, and abducting the other.

The personnel of the expedition included amongst others Dr. T. D. Campbell, to whom much of the credit of its success is due, Professors T. Harvey Johnston, C. S. Hicks and J. B. Cleland, Dr. H. K. Fry, Mr. H. M. Hale, director of the South Australian Museum, and Messrs. N. B. Tindale and J. H. Gray. As on previous occasions, the natives submitted themselves to many kinds of tests, some of them very trying, without the slightest murmur or objection.

Their good humor and sense of fun were again shown to a striking degree. Not the slightest attempt was made by any native to abstract articles from the camp, even though they could very easily have done so and must have coveted many of the objects seen. Any article accidentally lost by the party was almost invariably found by the natives and returned; one member, whilst watching a corroboree at night, dropped, without knowing it, two postage stamps: these were picked up and returned to camp, evidently being recognized as something unusual.

As the expedition had only a short time at its disposal, the study of the natives had to be concentrated. In physical anthropology this is an advantage; the native readily tires and novelty soon wears off. It would be probably difficult to hold together a body of 100 natives for a period as long as a month; many would desire before then to go for a "walk about."

Professor Hicks with his assistants studied each day the basal metabolism of two fresh natives. This was accompanied by a close study of the pulse and respiration rates, and of the body and skin temperatures throughout the morning as the warmth increased.

[1] Died February 28, 1933.

The natives were weighed and measured according to the Du Bois linear formula method of determining surface area, as well as for standing and sitting heights. Blood pressures were also measured, and katathermometer readings and wet and dry temperature measurements were obtained to give a basis for computing cooling power. When these data and those obtained previously are worked out it is hoped that conclusions may be drawn as to whether there is a true racial variation in basal metabolism; and whether the specific dynamic effect of protein meals on these natives, living with so little margin above a bare sustenance, is the same as for civilized Europeans; and that other important information will be obtained.

Blood-grouping showed again that only Groups A and O occur amongst the Central Australian natives. Out of 84 examined, 32 belonged to Group O and 52 to Group A.

Dr. Fry found that the class system of the Pintubi, which composed the majority of the natives, was of the 4-class nomenclature, but with the additional recognition of the 8-class of the adjacent Loritja. The legends and songs in relation to five ceremonies were obtained, together with their translations. Conception stories and dreams were obtained from five mothers.

Three hundred photographs were taken, which included standard photographs of bust and full-length, and a number of others concerning ceremonial records, pathological data and special features. Complete plaster casts were secured of the busts, including the faces, of two old men, of two young men, of two adult women, of one young woman, and of one newly born male baby; and a face cast of one young woman.

Pathological observations were recorded. The presence in some subjects to a slight degree of boomerang legs, and in several instances a soft enlargement of the parotid glands on each side was noted. Almost without exception pediculi were present in the hair.

It is the custom amongst these people for the mother to kill at birth an infant who is born whilst she is suckling its predecessor. The new-born baby, whose plaster cast was obtained, had been killed by its mother and stuffed into a rabbit's burrow, almost at the moment of arrival of the expedition at Mt. Liebig. Next day members became aware of this event, and with the concurrence of the natives and their assistance the body of the baby was unearthed and a complete description of it obtained. The placenta was attached. Soil or ashes are placed in the baby's mouth to stop its cries before the mother kills it.

Dr. T. D. Campbell and Mr. H. Gray obtained further standard records of measurements of adults and children, together with samples of hair, outlines of hair tracts, notes on the teeth and on the color of the skin, hair and eyes, and special information as regards the curve of the spine, shape of the foot, etc. The peculiar rubbery texture of the soles of the feet was again seen in a number of natives, but not in all.

Extensive cinematograph records were obtained of ceremonies, of daily occupations, of collecting and preparing foods, of making weapons and utensils, and of the meeting of two friendly parties of natives. Various animal and vegetable foods used by these natives were collected.

A meteorological equipment was taken and a very useful set of climatic records was obtained. Other incidental studies, such as geology and physiography, helped in an appreciation of the natives' physical environment.

The expedition proved successful, and has emphasized the value of team-work and the amount of information that can be collected in a short period of time by an intensive study.

J. B. CLELAND

SCIENTIFIC APPARATUS AND LABORATORY METHODS

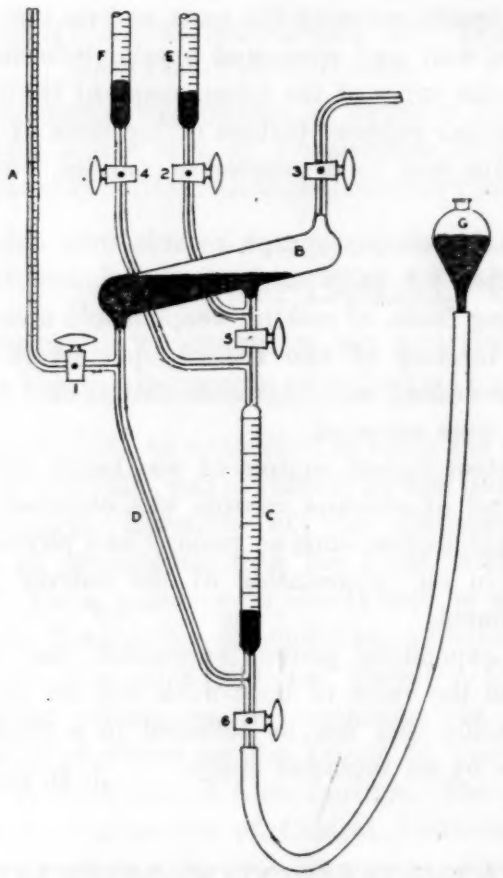
A UNIVERSAL DILATOMETER

SINCE the publication of Ostwald's work on "Volume Chemistry" in 1877, several papers have appeared, discussing from a theoretical and experimental point of view the change of volume which takes place during the process of neutralization of an acid by a base. Ostwald[1] first noticed the phenomenon and investigated its relation to the nature of the acid and of the base. His work was extended and confirmed by Ruppin.[2] The influence of the concentration was then studied by Tammann,[3] who worked with solutions of concentrations between 0.1 and 0.005 normal and who proposed an hypothesis to explain the change of volume. An extensive experimental investigation was later carried out by Miss Freund,[4] who concerned herself with the influence of temperature and of the concentration at higher concentrations than those with which Tammann had worked. During the course of a physico-chemical study of the process of neutralization, Cornec[5] determined the densities of mixtures of solutions of potassium hydroxide and

[1] W. Ostwald, *Jour. prakt. Chem.*, 16: 385, 1877.
[2] E. Ruppin, *Zeit. physik. Chem.*, 14: 467, 1894.
[3] G. Tammann, *Zeit. physik. Chem.*, 16: 91, 139, 1895.
[4] I. Freund, *Zeit. physik. Chem.*, 66: 555, 1909.
[5] E. Cornec, *Ann. chim. phys.*, (8) 29: 490, 1913.

phosphoric acid and by plotting density against molecular composition, there were shown decided breaks in the density-composition curve corresponding to the salts KH_2PO_4 and K_2HPO_4. More recently Saslawsky and Standel[6] have determined the volume change upon mixing solutions of acids and bases not only at the neutralization point but also in a series of mixtures of the constituents in other proportions. While their work is not intended to be of an accuracy comparable to any of that previously performed, it is of value in that it covers the concentration range from about 2 to 12 normal.

All the above work was performed by determining experimentally the densities of the solutions of the acid and base, and of the salt formed upon neutralization, and from these values, calculating the volume change taking place upon the formation of the salt



solution. As several of these investigators have pointed out, the value of the volume change so calculated depends upon the precision of the density determinations. Owing to the care necessary for the precise estimation of the density of a solution, even when allowing an error of ± 0.00005, it was thought that a dilatometric method, whereby the volume change might be directly observed, would expedite the extension of this type of work. The changes of volume accompanying oxidation-reduction reactions and those reactions involving the formation of complexes, for example, have not as yet been studied although they have occasionally been utilized for other purposes.[7]

To this end an apparatus has been devised, as illustrated diagrammatically in the accompanying figure, with which it is possible to add known volumes of one liquid to a known volume of another, and, after equilibrium has been established, to read directly the volume change which has occurred. It is based upon a simple hydrostatic principle, which will be obvious after a description has been given of the method of use.

The apparatus, set in a thermostat at the required temperature, is filled with mercury from the reservoir G through stop-cock 6. Stop-cocks 1, 2, 3, 4 and 5 are opened and the mercury allowed to rise into the burettes E and F, into the capillary A, and into the outlet tube through stop-cock 3. All the stop-cocks are then closed. The burettes E and F are filled with the liquids under investigation, note being taken of the amount in E. In opening stop-cocks 4 and 6 and lowering the mercury reservoir, the liquid in F flows down to fill the burette C. The stop-cocks are then closed. On opening stop-cocks 2 and 6 the liquid in E flows through 2, bubbles up through the mercury in B and occupies the upper portion of the tube. Meanwhile the mercury flows through D to the reservoir. When the required amount of liquid from E has been transferred to B, the flow of mercury is reversed by raising the reservoir, sending mercury back up again into the burette E. The difference between the volume of the liquid remaining and of that originally present in E gives the volume transferred to B. Stop-cock 2 is now closed. By opening stop-cock 1 the position of the mercury in the capillary A may now be adjusted to a suitable portion of the scale, depending upon whether the alteration of volume to be measured is an expansion or a contraction. Stop-cock 6 is closed. The thread of mercury running from B to C through stop-cock 5 is removed by opening the latter till the liquid in C rises to the constriction just at the entrance to B. The apparatus is now in the condition depicted.

The level of the mercury in C is noted and also the volume of the closed-off system as measured at A. Portions of the liquid in C are allowed to pass up into B by opening and then closing stop-cock 5. To insure thorough mixing of the two liquids, the tube B is at a slight angle to the horizontal so that by rocking the apparatus sideways, the motion of the mercury layer sets up a turbulence in the liquid above it. Any volume change which occurs will be evident from the displacement of the meniscus of the mercury in the capillary A. Opening and closing stop-cock 5, observing the change of height of the mercury in C,

[6] I. I. Saslawsky and E. G. Standel, *Zeit. anorg. allgem. Chem.*, 180: 241, 1929; 186: 171, 1930.

[7] A. Benrath, *Jour. prakt. Chem.*, 80: 283, 1909.

and measuring the volume on A, gives a complete record of the changes of volume taking place upon mixing the two liquids. The outlet through 3 has been introduced for the purpose of discarding the solutions after use and for cleaning.

In the apparatus as built, the tube B has a volume of approximately 120 cm³ with a length of about 20 cm and a diameter of about 3 cm. The burettes C, E and F are graduated for a volume of 50 cm³ by 1/10 cm³. The capillary A is graduated in millimeters over a length of 80 cm. To facilitate its mounting upon the frame of the apparatus, the capillary was wound into the form of a flat spiral with an average diameter of about 12 cm. Its volume after bending was calibrated with mercury in the usual way. One millimeter has a volume of 0.0021 cm³.

Besides being of use in the study of neutralization and of other chemical reactions between solutions, the dilatometer should be of value for the investigation of volume changes under many other conditions. The expansions or contractions taking place upon dilution of concentrated solution have been incompletely studied. To date the phenomenon has been investigated with only a few of the many electrolytes,[8] with alcohol[9] and with a few other organic compounds. Solutions of substances in other solvents than water have been almost completely neglected. The relation between the miscibility of liquids and the accompanying volume change may perhaps be a fruitful source for information concerning the nature of the liquid state and of solutions.

Another form of dilatometer with which it is possible to measure directly the alterations of volume on mixing two liquids has just recently been described.[10] Its applicability to work of a general nature is limited in that the volume change is given on mixing the two liquids in only one proportion. It is obvious that with the dilatometer described above the value of the volume changes for a series of mixtures of the two liquids may be obtained in one experiment.

Further details concerning the design, construction and manipulation of the apparatus, as well as some of the results obtained by its use, will be published in more extended form elsewhere. This notice has been given for the description of a new type of dilatometer, constructed easily and at small cost, which may facilitate greatly the study of a fundamental property of liquids.

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[8] G. P. Baxter and C. C. Wallace, *Jour. Amer. Chem. Soc.*, 38: 70, 1916.

[9] F. L. Teed, "Volume Alterations on and in Solution," London, 1926.

[10] J. H. Hildebrand and J. M. Carter, *Jour. Amer. Chem. Soc.*, 54: 3592, 1932.

PERMANENT SLIDES FOR USE IN TEACHING THE HOWARD METHOD

MANY food analysts throughout the country are employing the Howard method[1] of testing various comminuted food products to determine the condition of the raw material as regards decomposition due to mold, and it frequently happens that analysts come to this laboratory for instruction in the technique of the method. In the course of his training it has been customary for an experienced analyst to check field by field with the student analyst in order to determine the ability of the student to recognize mold filaments of various types. However, a saving in time would result if, instead of using the standard Howard cell, permanent slides with clearly defined fields marked on them were employed.

The preparation of such slides has been accomplished in the following manner: Tomato pulp or catsup of rather thin consistency is used for the test material. One and one half per cent. (1.5 per cent.) of agar is added to the sample and dissolved by boiling. Before cooling, 4 to 5 per cent. of commercial formaldehyde is added.

The following method of delimiting the fields has been found most advantageous. Twenty-five perforations, each 1.31 mm in diameter, are made in colored cellophane, the holes being spaced about 1 mm apart and arranged in five rows of five holes each. This particular sized perforation was used since it is just slightly smaller than the field specified for use in the Howard method, namely 1.382 mm in diameter. A punch for making the holes can conveniently be made by cutting off a 0.052 inch drill at the upper limit of the twist and placing the shank in a suitable holder. By placing the cellophane over a hard fiber board it is readily possible with a hammer to make clean-cut perforations. A special die has been found useful in cutting the holes, although this is not necessary. The excess cellophane at the edge of the square is trimmed off, leaving a narrow margin of about 0.5 mm.

The cellophane mask is cemented to a clean microscope slide with the aid of balsam and covered with a cover glass. After the balsam is dry, a drop of the tomato agar preparation, previously softened in a boiling water bath, is placed on the cover glass and quickly spread out into a thin layer by means of a second cover slip. Excess pulp is removed after it hardens and the whole is sealed by ringing with balsam.

When ready for use, each field is examined for the presence or absence of mold filaments of the required length and a permanent record is made to accompany the slide.

J. D. WILDMAN

U. S. DEPARTMENT OF AGRICULTURE

[1] "Methods of Analysis," Assn. of Official Agric. Chemists, pp. 400–401.

SPECIAL ARTICLES

THE DISTRIBUTION OF AMERICAN MEN OF SCIENCE IN 1932

FOR the fifth edition of the "Biographical Directory of American Men of Science" there have been selected by objective methods 250 of those not included in the earlier selections who are regarded by their colleagues as among the leading scientific workers of the United States. The methods used were the same as in the fourth edition; there and in the earlier editions they were fully described and their validity was discussed in detail.[1]

The primary object of the work, begun more than thirty years ago, was to secure a group for scientific study. Still earlier there had been selected by objective methods the thousand most eminent men of history, and measurements had been made of nearly a thousand students of Columbia University. Each of the three groups is suited to scientific study, owing to its sociological interest and to the availability of the material. At that time but little attention had been paid to the measurement of individual differences, the present writer having in 1885 invented the term and published the first quantitative work on the subject.

Arguments may be advanced for and against giving the names of the scientific men selected for study. Each of them is probably among our thousand leading research workers, but there are others who deserve to be included. The situation is the same as in election to an academy of sciences or appointment to a university position, except that the determination of scientific merit is more exact. We also have an analogous problem in the measurement of the ability of a child or a college student.

It is sometimes argued that all such determinations are undemocratic. Democracy, however, does not consist in reducing all to a common mediocracy, but in giving opportunity to each in accordance with his ability and fitness. We long have had school grades, college entrance examinations, requirements for the doctorate, qualifications for a university position, honorary degrees, and societies of limited membership. In so far as psychology is gradually developing quantitative methods to measure individual differences the results may at times seem harsh and inconsiderate of the individual; but in the long run truth is better than illusion.

While there are those who do not approve the selection of a group of leading scientific workers, others urge that the stars should be dropped when a position among the thousand is not maintained. The competition in the earlier selections was less severe, for in 1903 there were only about 4,000 Americans who had published research work, whereas now there are more than 20,000. It is also true that some men do not maintain the promise of their earlier work. A selection which is correct at the time within the limits of the probable error may not hold thirty years later. In order to make the situation definite and to supply information that may be of historical interest, there will be given in the new edition of the book an index number with the star, showing the edition in which the individual was added to the list.

As the number of entries in the book is now so large, it may be desirable to give the list of those to whom stars have been assigned in the fifth edition. The date of reference is approximately January 1, 1932, subsequent changes of address being given in brackets. The 250 names are as follows:

Anatomists

Edgar Allen, University of Missouri
George W. Bartelmez, University of Chicago
Edward A. Boyden, University of Minnesota
J. L. Bremer, Harvard University
Hal Downey, University of Minnesota
George B. Wislocki, Harvard University

Anthropologists

Ruth Benedict, Columbia University
Fay-Cooper Cole, University of Chicago
Ralph Linton, University of Wisconsin
Frank H. H. Roberts, Jr., Smithsonian Institution
Leslie Spier, Yale University

Astronomers

R. T. Crawford, University of California
Milton L. Humason, Mt. Wilson Obs., Carnegie Inst.
Hamilton M. Jeffers, Lick Obs., Univ. of California
Dean B. McLaughlin, Detroit Obs., Univ. of Michigan
Donald H. Menzel, Lick Obs., Univ. of Calif. [Harvard]
Herbert R. Morgan, U. S. Naval Observatory
H. H. Plaskett, Harvard College Obs., [Oxford Univ.]
R. F. Sanford, Mt. Wilson Obs., Carnegie Institution
E. C. Slipher, Lowell Observatory
Harlan True Stetson, Perkins Obs., Ohio Wesleyan Univ.
J. Q. Stewart, Princeton University
Otto Struve, Yerkes Observatory, University of Chicago
Ralph E. Wilson, Dudley Observatory

Botanists

H. A. Allard, U. S. Department of Agriculture
S. F. Blake, U. S. Department of Agriculture
John T. Buchholz, University of Illinois
Roy E. Clausen, University of California

[1] In order to prevent misunderstandings that occur, it may be stated here: (1) The present writer has devised the methods and compiled the returns, but, apart from casting one vote for the psychologists, has had no part whatever in the selections. (2) Residents of North America are included in the book, but only residents of the United States in the selections for the stars. (3) The applied sciences as such are not included. (4) When an individual is selected in more than one science, he is assigned to the science in which he stands highest. (5) The subject of research given in the book is usually, but not always, the subject in which the star has been assigned.

William S. Cooper, University of Minnesota
Otis F. Curtis, Cornell University
F. E. Denny, Boyce Thompson Institute
Carroll W. Dodge, Missouri Botanical Garden
J. Horace Faull, Arnold Arboretum, Harvard University
H. S. Fawcett, Citrus Exp. Sta., University of California
H. M. Fitzpatrick, Cornell University
T. H. Goodspeed, University of California
R. B. Harvey, University of Minnesota
Chas. F. Hottes, University of Illinois
D. F. Jones, Connecticut Experiment Station
Irving E. Melhus, Iowa State College
Raymond J. Pool, University of Nebraska
Alfred Rehder, Arnold Arboretum, Harvard University
William J. Robbins, University of Missouri
Karl Sax, Harvard University
Fred. J. Seaver, New York Botanical Garden
William Seifriz, University of Pennsylvania
Gilbert M. Smith, Stanford University
W. Randolph Taylor, University of Michigan
Sam F. Trelease, Columbia University

Chemists

Homer Adkins, University of Wisconsin
Rudolph J. Anderson, Yale University
Donald H. Andrews, Johns Hopkins University
F. Russell v. Bichowsky, Naval Research Laboratory
Arthur M. Buswell, University of Illinois
Wallace H. Carothers, E. I. du Pont de Nemours and Co.
George L. Clark, University of Illinois
E. J. Cohn, Harvard Medical School
Louis F. Fieser, Harvard University
N. Howell Furman, Princeton University
Reynold C. Fuson, University of Illinois
W. F. Giauque, University of California
G. E. Gibson, University of California
Henry Gilman, Iowa State College
Michael Heidelberger, Columbia University
Arthur J. Hill, Yale University
Charles D. Hurd, Northwestern University
W. A. Jacobs, Rockefeller Institute
John R. Johnson, Cornell University
Oliver Kamm, Parke, Davis and Company
M. S. Kharasch, University of Chicago
George B. Kistiakowsky, Harvard University
I. M. Kolthoff, University of Minnesota
Victor K. LaMer, Columbia University
Wendell M. Latimer, University of California
J. W. MacBain, Stanford University
Edward Mack, Jr., Ohio State University
Carl S. Marvel, University of Illinois
Leonor Michaelis, Rockefeller Institute
Thomas Midgley, Jr., Ethyl Gasoline Corporation
Julius Arthur Nieuwland, University of Notre Dame
John H. Northrop, Rockefeller Institute
W. Albert Noyes, Jr., Brown University
Linus Pauling, California Institute of Technology
Robert N. Pease, Princeton University
F. O. Rice, Johns Hopkins University
George Scatchard, Massachusetts Institute of Technology
H. I. Schlesinger, University of Chicago
Charles P. Smyth, Princeton University
C. M. A. Stine, E. I. du Pont de Nemours and Co.
E. C. Sullivan, Corning Glass Works
E. H. Volwiler, Abbott Laboratories
H. H. Willard, University of Michigan
John Arthur Wilson, Milwaukee, Wisconsin

Geologists

Ernst Antevs, Auburn, Maine
Donald C. Barton, Houston, Texas
Alan M. Bateman, Yale University
Kirk Bryan, Harvard University
Walter H. Bucher, University of Cincinnati
S. R. Capps, U. S. Geological Survey
Ralph W. Chaney, University of California
J. A. Cushman, Sharon, Massachusetts
C. N. Fenner, Geophysical Laboratory, Carnegie Inst.
Henry G. Ferguson, U. S. Geological Survey
Aug. F. Foerste, Dayton, Ohio [U. S. Nat. Museum]
Charles W. Gilmore, U. S. National Museum
Frank L. Hess, U. S. Bureau of Mines
G. F. Kay, University of Iowa
F. H. Lahee, Sun Oil Company
Morris M. Leighton, Illinois State Geological Survey
Chester R. Longwell, Yale University
H. E. Merwin, Geophysical Laboratory, Carnegie Inst.
Raymond C. Moore, University of Kansas
John B. Reeside, Jr., U. S. Geological Survey
Clarence Samuel Ross, U. S. Geological Survey
E. H. Sellards, University of Texas
W. T. Thom, Jr., Princeton University
Chester K. Wentworth, Washington Univ. (St. Louis)
Wendell P. Woodring, U. S. Geological Survey

Mathematicians

C. Raymond Adams, Brown University
A. Adrian Albert, Columbia University [Univ. Chicago]
Jesse Douglas, Massachusetts Institute of Technology
Lester R. Ford, Rice Institute
Tomlinson Fort, Lehigh University
Thornton C. Fry, Bell Telephone Laboratories
Lawrence M. Graves, University of Chicago
Mark H. Ingraham, University of Wisconsin
Rudolph E. Langer, University of Wisconsin
C. C. MacDuffee, Ohio State University
John v. Neumann, Princeton University
Oystein Ore, Yale University
Tibor Radó, Ohio State University
M. H. Stone, Yale University
Dirk J. Struik, Massachusetts Institute of Technology
T. Y. Thomas, Princeton University
J. V. Uspensky, Stanford University
Gordon T. Whyburn, Johns Hopkins University
D. V. Widder, Harvard University
R. L. Wilder, University of Michigan

Pathologists

T. Addis, Stanford University
S. Bayne-Jones, University of Rochester [Yale Univ.]
A. E. Cohn, Rockefeller Institute
Walter E. Dandy, Johns Hopkins University
Edward Francis, National Institute of Health
Evarts A. Graham, Washington University (St. Louis)
Alfred F. Hess, N. Y. Univ. and Bellevue Hosp. Med. Col.
Esmond R. Long, University of Chicago [Phipps Inst.]

K. F. Meyer, Hooper Foundation, Univ. of California
George R. Minot, Harvard University
Arnold R. Rich, Johns Hopkins University
T. M. Rivers, Rockefeller Institute
Carl TenBroeck, Rockefeller Institute
Augustus Wadsworth, N. Y. State Department of Health
Leslie T. Webster, Rockefeller Institute

Physicists

Samuel K. Allison, University of Chicago
J. W. Beams, University of Virginia
J. A. Bearden, Johns Hopkins University
Joseph A. Becker, Bell Telephone Laboratories
Robert B. Brode, University of California
Edw. U. Condon, Princeton University
David M. Dennison, University of Michigan
G. H. Dieke, Johns Hopkins University
Lee A. DuBridge, Washington University (St. Louis)
O. S. Duffendack, University of Michigan
Carl Eckart, University of Chicago
A. Ellett, University of Iowa
L. H. Germer, Bell Telephone Laboratories
R. Clifton Gibbs, Cornell University
Samuel A. Goudsmit, University of Michigan
Ross Gunn, Naval Research Laboratory
G. R. Harrison, Massachusetts Institute of Technology
William V. Houston, California Institute of Technology
J. C. Hubbard, Johns Hopkins University
Thomas H. Johnson, Bartol Research Foundation
Alfred Landé, Ohio State University
Otto Laporte, University of Michigan
Ernest O. Lawrence, University of California
Alfred L. Loomis, Tuxedo Park, N. Y.
F. W. Loomis, University of Illinois
Philip M. Morse, Massachusetts Institute of Technology
Otto Oldenberg, Harvard University
J. R. Oppenheimer, California Institute of Technology
A. G. Shenstone, Princeton University
Lewi Tonks, General Electric Company
L. B. Tuckerman, U. S. Bureau of Standards
Louis A. Turner, Princeton University
M. A. Tuve, Dept. Terrestrial Magnetism, Carnegie Inst.
G. E. Uhlenbeck, University of Michigan
H. C. Urey, Columbia University
William W. Watson, Yale University
Fritz Zwicky, California Institute of Technology

Physiologists

H. C. Bazett, University of Pennsylvania
G. H. Bishop, Washington University (St. Louis)
McKeen Cattell, Cornell University Medical College
Carl F. Cori, Washington University (St. Louis)
Edward A. Doisy, St. Louis University
J. G. Dusser de Barenne, Yale University
Wallace O. Fenn, University of Rochester
John F. Fulton, Yale University
Frank A. Hartman, University of Buffalo
Harry Steenbock, University of Wisconsin

Psychologists

John E. Anderson, University of Minnesota
Karl M. Dallenbach, Cornell University
J. F. Dashiell, University of North Carolina
Samuel W. Fernberger, University of Pennsylvania
Frank N. Freeman, University of Chicago
Clark L. Hull, Yale University
H. M. Johnson, Mellon Institute [American Univ.]
K. Koffka, Smith College
Mark Arthur May, Yale University
Donald G. Paterson, University of Minnesota
Edward Stevens Robinson, Yale University
Calvin P. Stone, Stanford University
Edward C. Tolman, University of California

Zoologists

Leslie B. Arey, Northwestern University
Robert A. Budington, Oberlin College
Asa C. Chandler, Rice Institute
Royal N. Chapman, University of Hawaii
C. H. Danforth, Stanford University
J. Frank Daniel, University of California
A. B. Dawson, Harvard University
L. V. Domm, University of Chicago
L. C. Dunn, Columbia University
Paul S. Galtsoff, U. S. Bureau of Fisheries
H. B. Goodrich, Wesleyan University
Frank Blair Hanson, Washington Univ. (St. Louis)
Selig Hecht, Columbia University
Leigh Hoadley, Harvard University
Davenport Hooker, University of Pittsburgh
Carl L. Hubbs, Museum of Zoology, Univ. of Michigan
Libbie H. Hyman, University of Chicago
W. A. Kepner, University of Virginia
George R. La Rue, University of Michigan
E. Carleton MacDowell, Sta. Exp. Evolution, Carnegie Inst.
James W. Mavor, Union College
A. L. Melander, College of the City of New York
Dwight E. Minnich, University of Minnesota
Ann Haven Morgan, Mt. Holyoke College
Charles Packard, Crocker Inst. Cancer Research, Columbia
Bradley M. Patten, Western Reserve University
Harold H. Plough, Amherst College
Alfred C. Redfield, Harvard University
W. A. Riley, University of Minnesota
Franz Schrader, Columbia University
C. C. Speidel, University of Virginia
H. W. Stunkard, New York University
C. V. Taylor, Stanford University
H. J. Van Cleave, University of Illinois
B. H. Willier, University of Chicago
Emil Witschi, University of Iowa
A. H. Wright, Cornell University

The 250 individuals whose names are given above have been selected from more than 20,000; consequently each of them stands first among more than eighty research workers, a somewhat severe selection. It is not feasible to give at this time the number and distribution of the some 22,000 entries in the edition of the directory now in press. 12,877 names in the fourth edition were distributed, according to the sections of the American Association for the Advancement of Science, as shown in the table.

TABLE I. DISTRIBUTION AMONG THE SCIENCES

Mathematics	756
Physics	991
Chemistry	2,561
Astronomy	239
Geology and Geography	903
Zoology	1,435
Botanical Sciences	1,187
Anthropology	111
Psychology	539
Social and Economic Sciences	23
Historical and Philological Sciences	37
Engineering	1,245
Medical Sciences	2,027
Agriculture	769
Education	54
Total	12,877

If the applied sciences are omitted (though all those included in the book were understood to have advanced science by research) and the classification adopted in these studies is used, the number is 9,785 and the distribution is as shown in the first column of Table II.

TABLE II. DISTRIBUTION AMONG THE FUNDAMENTAL SCIENCES

	All	Women	Per cent. women
Mathematics	756	61	8.0
Physics	991	28	2.1
Chemistry	2561	117	4.6
Astronomy	239	23	9.6
Geology	903	32	3.5
Botany	1187	119	10.0
Zoology	1436	130	9.0
Physiology	460	48	10.4
Anatomy	206	11	5.4
Pathology	396	28	7.1
Anthropology	111	11	9.9
Psychology	539	117	22.0
Total	9785	725	7.4

In the group of 250 there are three women. There are two in the National Academy of Sciences with about the same number of members. There are 725 women included in the book distributed (all of them being assigned to the twelve sciences) as shown in Table II. The percentage of women in each science is also given. It ranges from 2.1 per cent. in physics to 22 per cent. in psychology. The preponderance in the latter subject is due in the main to the large number of teaching and clinical positions open to women.

The average age of the 250 in the group is 42.9 years. Distinction is attained at an earlier age in mathematics and the exact sciences than in the natural sciences, the average age in the different sciences being as shown.

TABLE III. AVERAGE AGE IN THE DIFFERENT SCIENCES

Mathematicians	36.1
Physicists	36.0
Chemists	41.1
Astronomers	42.9
Geologists	49.4
Botanists	47.0
Zoologists	45.3
Physiologists	42.0
Anatomists	47.7
Pathologists	48.3
Anthropologists	41.8
Psychologists	44.0

In Table IV there is given under 1932 the distribution by states of the birthplace and residence of the 250 scientific men now added to the list. The numbers are multiplied by four in order to show comparisons with the earlier selections. There were 1,000 in 1903. The additions in 1910 were 269; in 1921 (the interval having been prolonged by the war) 351; in 1927, 250. The 601 names of 1921 and 1927 were considered together in the fourth edition of the directory. In the table all the figures are placed on the basis of a thousand entries, decimals being omitted.

While the numbers for most of the states are so small that they have only a limited validity, the general distribution of the scientific population in 1903 and its subsequent movements are clearly shown. Of the thousand scientific men of 1903, 134 were born in Massachusetts and 40 in Connecticut. This represents a birth rate of 108.8 per million population in Massachusetts, and of 86.9 in Connecticut, the population being based on the census of 1860. The birth rate is then reduced to about half in the surrounding states, being 47.2 in New York. There is a further reduction to one half in Pennsylvania, where it is 22.7, and this continues southward, the rate being 8.8 in Virginia, 5 in North Carolina, 2.8 in Georgia, 2.1 in Alabama, 1.3 in Mississippi and 1.4 in Louisiana. In the north central states the conditions are intermediate between New York and Pennsylvania and decrease southward.

The change in distribution of the birthplaces in the later selections is very significant for such a short period in the history of the nation. New England has lost its supremacy in the production of scientific men, the numbers from Massachusetts on the basis of a thousand, decreasing from 134 in 1906 to 100 in 1910, 80 in 1921–27, 72 in 1932. The corresponding figures for Connecticut are 40, 22, 27 and 16. The rural New England states fail even more in productivity. New York, New Jersey, Pennsylvania and Maryland also decrease. The gains are especially in the central

TABLE IV. BIRTHPLACE AND RESIDENCE OF SCIENTIFIC MEN SELECTED AT FOUR PERIODS

	Birthplace				Residence			
	1903	1910	1921–27	1932	1903	1910	1921–27	1932
North Atlantic								
Maine	29	22	10	8	4	7	2	4
New Hampshire	15	11	12	.....	8	4	5	.....
Vermont	18	11	10	8	2	.....	.....	.....
Massachusetts	134	100	80	72	144	160	95	100
Rhode Island	5	15	2	4	8	11	7	8
Connecticut	40	22	27	16	43	60	33	56
New York	183	134	111	128	192	141	203	164
New Jersey	28	15	13	12	35	19	30	44
Pennsylvania	66	52	68	48	65	48	63	28
South Atlantic								
Delaware	2	.....	3	.....	1	.....	2	8
Maryland	26	7	22	4	47	48	38	32
District of Columbia	3	4	5	8	119	97	128	76
Virginia	13	26	13	4	10	.....	5	12
West Virginia	1	7	7	4	3	4	3	.....
North Carolina	5	.....	8	4	6	11	3	4
South Carolina	5	11	7	4	.....	.....	2	.....
Georgia	3	4	5	8	1	.....	.....	.....
Florida	.....	4	.....	.....	.....	.....	.....	.....
South Central								
Kentucky	8	7	8	4	3	.....	2	.....
Tennessee	6	7	7	4	3	.....	5	.....
Alabama	2	7	3	4	2	.....	.....	.....
Mississippi	1	4	3	.....	.....	.....	.....	.....
Louisiana	1	.....	2	8	1	4	2	.....
Texas	3	7	2	4	7	7	13	20
Oklahoma	.....	.....	2	.....	.....	.....	2	.....
Arkansas	.....	.....	3	.....	.....	.....	.....	.....
North Central								
Ohio	75	86	81	72	34	37	33	40
Indiana	28	45	30	36	12	19	8	4
Illinois	42	52	75	88	63	104	86	96
Michigan	27	63	22	16	27	19	30	48
Wisconsin	35	41	40	20	23	48	18	28
Minnesota	4	19	23	32	13	11	30	36
Iowa	20	33	45	32	7	4	7	20
Missouri	14	19	35	40	21	22	13	40
North Dakota	.....	.....	2	.....	2	.....	.....	.....
South Dakota	.....	.....	5	8	2	4	.....	.....
Nebraska	2	4	10	20	9	15	3	4
Kansas	7	.....	18	32	5	7	8	4
Western								
Montana	.....	.....	3	.....	2	.....	.....	.....
Wyoming	.....	.....	3	4	1	.....	3	.....
Colorado	3	.....	2	16	8	7	3	.....
New Mexico	.....	.....	.....	8	2	.....	.....	.....
Arizona	.....	.....	.....	4	2	4	7	4
Utah	.....	.....	5	.....	.....	.....	.....	.....
Nevada	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	.....	.....	.....	.....	.....	.....	.....	.....
Washington	1	.....	.....	12	.....	.....	2	.....
Oregon	.....	4	2	4	.....	4	.....	.....
California	11	15	18	20	53	56	78	116
Territories and Dependencies								
Porto Rico	.....	.....	.....	.....	1	.....	2	.....
Alaska	.....	.....	.....	.....	1	.....	.....	.....
Hawaii	1	4	.....	.....	.....	4	.....	4
Philippines	.....	4	.....	.....	3	7	.....	.....
Panama	.....	.....	.....	.....	.....	4	.....	.....
Foreign								
Canada	34	33	30	36	2	.....	5	.....
Brazil	.....	.....	.....	.....	1	.....	.....	.....
Cuba	.....	.....	.....	.....	1	.....	.....	.....
West Indies	1	.....	.....	.....	.....	.....	.....	.....
England	25	.....	35	8	1	.....	.....	.....
Scotland	9	15	7	12	.....	.....	.....	.....
Wales	1	.....	.....	.....	.....	.....	.....	.....
Ireland	3	4	2	.....	.....	.....	.....	.....
Germany	19	22	12	36	.....	.....	.....	.....
Austria-Hungary	6	.....	.....	.....	.....	.....	.....	.....
Austria	.....	.....	7	4	.....	.....	.....	.....
Hungary	.....	.....	.....	8	.....	.....	.....	.....
Norway	1	4	.....	4	.....	.....	.....	.....
Sweden	3	7	5	8	.....	.....	.....	.....
Denmark	2	.....	2	.....	.....	.....	.....	.....
Holland	.....	.....	5	16	.....	.....	.....	.....
Belgium	.....	.....	2	4	.....	.....	.....	.....
Poland	.....	.....	3	.....	.....	.....	.....	.....
Bulgaria	.....	.....	.....	4	.....	.....	.....	.....
Czecho-Slovakia	.....	.....	.....	4	.....	.....	.....	.....
Switzerland	8	.....	8	8	.....	4	.....	.....
Italy	1	.....	.....	.....	.....	.....	.....	.....
Spain	1	.....	.....	.....	.....	.....	.....	.....
Russia	6	11	13	12	.....	.....	.....	.....
Turkey	.....	.....	3	.....	.....	.....	.....	.....
Syria	.....	.....	3	.....	.....	.....	.....	.....
India	4	.....	.....	.....	.....	.....	.....	.....
Mongolia	.....	.....	.....	4	.....	.....	.....	.....
China	2	.....	.....	.....	.....	.....	.....	.....
Japan	.....	7	3	4	.....	.....	.....	.....
Siam	.....	.....	.....	.....	.....	.....	2	.....
Dutch E. Indies	.....	.....	.....	4	.....	.....	.....	.....
Australia	.....	.....	2	.....	.....	.....	.....	.....
South Africa	.....	.....	2	.....	.....	.....	2	.....

west, the record for Illinois being 42, 52, 75 and 88. There are also large increases in other north central states: Minnesota, 4 to 32; Iowa, 20 to 32; Missouri, 14 to 40; Nebraska, 2 to 20; Kansas, 7 to 32. The more easterly states of Ohio and Indiana remain about stationary. Twelve states south of Virginia supplied only 35 men to the list of 1903; they show some improvement in the subsequent selections, 58, 57 and 44.

The residence[2] of leading scientific men in the different states follows in general their production, but certain regions produce more than they retain or obtain, while in others the reverse is the case. Massachusetts and Connecticut have had in residence even more scientific men than they have produced. This holds also for New York and of course in the greatest measure for the District of Columbia. Ohio and Indiana, on the other hand, have in residence less than half as many leading scientific men as they have produced. California gained greatly in the last arrangement, being surpassed only by New York and having a much larger percentage per million population.

On the list of 1903 there were 126 scientific men born in foreign countries, contributed in very unequal

[2] The scientific men were selected in 1903; the residence is of January 1, 1906, as given in the first edition of the directory.

measure by different nationalities, the number per million foreign-born population being: Switzerland, 68.9; England, 29.6; Germany, 7.1; Italy, 2.1; France, 0. The relative numbers of scientific men born abroad in the subsequent selections were 103, 144 and 172. There have been in the selections following the war a large percentage of scientific men who migrated to this country after having attained distinction at home.

Table V gives the institutions from which the 250 scientific men received their academic degrees. Harvard is still in the lead by a wide margin, having granted 19 bachelor's degrees, 39 doctorates of philosophy or science and 4 doctorates of medicine. Chicago comes next with a total of 42 degrees, followed by Columbia with 29. There then follows a group coming close together, Cornell, Princeton, the Johns Hopkins, Yale, Illinois, and California, with a drop to about half as many at Michigan and Wisconsin. These figures represent the situation for those who received their degrees on the average some twenty years ago. Since then the number of advanced degrees conferred by the state universities has increased with great rapidity. The 27 not recorded as having had a bachelor's degree had in practically all cases an equivalent education, in most cases abroad. Two men hold doctorates of both philosophy and medicine, leaving only 17 who do not hold one of these degrees.

In Table VI are given the institutions with which three or more of the scientific men are connected. Harvard has sixteen and California 15, followed by Chicago, Yale, Michigan, Columbia and Princeton. Seven of the men are connected with the Rockefeller Institute for Medical Research and six with the Carnegie Institution of Washington.

TABLE V. THE INSTITUTIONS WHICH GRANTED THREE OR MORE OF THE DEGREES

	A.B. or B.S.	Ph.D. or Sc.D	M.D.	Total
Harvard	19	39	4	62
Chicago	13	28	1	42
Columbia	7	19	3	29
Cornell	9	11	.....	20
Princeton	6	13	.....	19
Johns Hopkins	2	10	6	18
Yale	5	12	.....	17
Illinois	7	10	.....	17
California	4	12	.....	16
Michigan	8	1	.....	9
Wisconsin	1	8	.....	9
Minnesota	5	3	.....	8
Brown	5	1	.....	6
Virginia	2	4	.....	6
Amherst	5	.....	.....	5
Ohio State	3	2	.....	5
Washington (St. L.)	3	2	.....	5
Kansas	4	.....	.....	4
Pennsylvania	2	2	.....	4
Stanford	3	1	.....	4
Texas	2	2	.....	4
Dennison	3	.....	.....	3
Iowa	1	2	.....	3
Missouri	3	.....	.....	3
Nebraska	2	1	.....	3
Swarthmore	3	.....	.....	3
Elsewhere	82	4	2	88
Total	209	187	16	412
Berlin	.....	3	1	4
Toronto	4	.....	.....	4
Edinburgh	2	.....	1	3
Leiden	.....	3	.....	3
Munich	.....	3	.....	3
Zurich	1	2	.....	3
Elsewhere	7	16	3	26
Total	14	27	5	46
Grand Total	223	214	21	458

TABLE VI. INSTITUTIONS WITH WHICH THREE OR MORE ARE CONNECTED

Harvard	16
California	15
Chicago	13
Yale	13
Michigan	11
Columbia	10
Princeton	10
Minnesota	9
Illinois	8
Johns Hopkins	8
Cornell	7
Rockefeller Institute	7
Stanford	7
Carnegie Institution	6
Washington (St. Louis)	6
Massachusetts Institute	5
U. S. Geol. Survey	5
Wisconsin	5
California Institute	4
Ohio State	4
Bell Tel. Labs.	3
Iowa	3
Pennsylvania	3
Virginia	3
Elsewhere	69
Total	250

The movement from the universities to the research institutions, industrial laboratories and government service, which was notable shortly after the war, has apparently now ceased. In the list of 1927 fifteen of the 250 men were connected with the Carnegie Institution; nine with the Geological Survey; seven with the Bell Telephone Laboratories; six with the Department of Agriculture; five each with the Rockefeller

Institute, the Bureau of Standards and the American Museum of Natural History; four with the Eastman Kodak Company and three with the U. S. Health Service.

There have been selected by the average space allotted to sketches in biographical directories and encyclopedias the leading scientific men of the United States who died prior to the present century. There are not as many as a thousand reaching the standard of the 22,000 in the present edition of the directory; it is necessary to include large numbers of physicians and inventors. Preparations have also been made to select the thousand leading scientific men of the world now living and the thousand most eminent who are no longer living. A study of distribution among the sciences, in different nations and at different periods, supplies the beginning of a quantitative study of history. It is also proposed to print biographical sketches in a subsequent edition of the directory. Some further study has been given to family relationship among scientific workers. It is of interest to note the considerable number of sons of scientific men who have attained high standing in the course of the past twenty years.

The change in standing of a scientific man after a period of years gives in quantitative units (with a probable error attached) his gain or loss in the judgment of his colleagues. The efforts of a lifetime are condensed into a single informing and dramatic figure. Data have been published showing that men under forty years of age are likely to gain in reputation; between forty and forty-five to remain about stationary; after that age to lose and increasingly as they grow older. The average gains or losses yield information concerning the effects of different situations, for example, at one university or another, at large or small institutions, in research institutions, in industrial laboratories, in the government service, with much or little administrative work or teaching, etc. The data may ultimately give information concerning individual differences in relation to heredity and social influences. But this is one of many studies that the present writer has been unable to complete.

When the scientific men were arranged in 1903 in order of merit it was stated that the lists would not be published within twenty years. Nearly thirty years having now elapsed it may be useful to make public a list that has considerable historical interest. The order gives no information concerning the contemporary position, some of those near the bottom of the selection in 1903 having now risen to the top and some of those then at the top having dropped. In the fifth edition of the directory, to be published this month, the list will be given in full. There are here printed in the order of merit for each science the hundred men of science regarded in 1903 by their colleagues as the most distinguished, the number in each science being approximately proportional to the total number of workers. The names of those no longer living are given in italics with the years of birth and death.

MATHEMATICS: *Eliakim Hastings Moore,* 62–3[illegible]; *George William Hill,* 38–14; W. F. Osgood; *Maxi[illegible] Bôcher,* 67–18; Oskar Bolza; F. Morley; Ernest W. Brown; H. S. White.

PHYSICS: *Albert Abraham Michelson,* 52–31; C[illegible] Barus; Edward L. Nichols; *Arthur Gordon Webste[illegible]* 63–23; *John Trowbridge,* 43–23; M. I. Pupin; *Ern[illegible] Fox Nichols,* 69–24; *Samuel Pierpont Langley,* 34–0[illegible] *DeWitt Bristol Brace,* 58–05; Elihu Thomson; *Robe[illegible] Simpson Woodward,* 49–24; *Charles Proteus Steinmet[illegible]* 65–23; *Henry Smith Carhart,* 44–20; Edwin H. Hall; J. S. Ames.

CHEMISTRY: *Ira Remsen,* 46–27; *Edward Willia[illegible] Morley,* 38–23; *Oliver Wolcott Gibbs,* 22–08; *Theodo[illegible] William Richards,* 68–28; *Edgar Fahs Smith,* 54–2[illegible] *John William Mallet,* 32–12; Russell H. Chittende[illegible] Arthur Michael; *John Ulric Nef,* 62–15; *Harvey Wa[illegible] ington Wiley,* 44–30; *James Mason Crafts,* 39–17; F. [illegible] *Gooch,* 52–29; C. L. Jackson; *William Francis Hil[illegible] brand,* 53–25; *William Olin Atwater,* 44–07; Arthur [illegible] Noyes; *Albert Benjamin Prescott,* 32–05.

ASTRONOMY: *Simon Newcomb,* 35–09; *Edward Charl[illegible] Pickering,* 46–19; *Lewis Boss,* 46–12; W. W. Campbell; *Seth Carlo Chandler,* 46–13.

GEOLOGY: *Thomas Chrowder Chamberlin,* 43–28; *Gro[illegible] Carl Gilbert,* 43–18; *Charles Doolittle Walcott,* 50–2[illegible] *Charles Richard Van Hise,* 57–18; *Samuel Frankl[illegible] Emmons,* 41–11; W. M. Davis; *John Casper Branne[illegible]* 50–22; *Nathaniel Southgate Shaler,* 41–06; *Clarenc[illegible] Edward Dutton,* 41–12; *Raphael Pumpelly,* 37–23.

BOTANY: *William Gilson Farlow,* 44–19; N. L. Bri[illegible] ton; *John Merle Coulter,* 51–28; W. Trelease; *Charl[illegible] Edwin Bessey,* 45–15; *Lucien Marcus Underwood,* 5[illegible] 07; L. H. Bailey; *Roland Thaxter,* 58–32; D. T. Mac[illegible] Dougal; B. L. Robinson.

ZOOLOGY: *William Keith Brooks,* 48–08; *Charles O[illegible] Whitman,* 42–10; *Alexander Agassiz,* 35–10; E. B. Wil[illegible] son; H. F. Osborn; *Charles Sedgwick Minot,* 52–14; [illegible] L. Mark; T. H. Morgan; W. M. Wheeler; *Samuel Hub[illegible] bard Scudder,* 37–11; Chas. B. Davenport; *David Star[illegible] Jordan,* 51–31; Edwin G. Conklin; C. Hart Merriam; *William Healey Dall,* 45–27.

PHYSIOLOGY: *Henry Pickering Bowditch,* 40–11; W. H. Howell; W. T. Porter; *Samuel James Meltzer,* 51–20.

ANATOMY: *Franklin Paine Mall,* 62–17; *George Sum[illegible] ner Huntington,* 61–27; H. H. Donaldson.

PATHOLOGY: William H. Welch; W. T. Councilman; Simon Flexner; *William Osler,* 49–19; Theobald Smith; *Theophil Mitchell Prudden,* 49–24.

ANTHROPOLOGY: Franz Boas; *Otis Tufton Mason,* 3[illegible] 08.

PSYCHOLOGY: *William James,* 42–10; J. McKee[illegible] Cattell; *Hugo Münsterberg,* 63–16; *Granville Stanle[illegible] Hall,* 46–24; J. Mark Baldwin.

J. MCKEEN CATTELL